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NOTES

We hope that you will find this Glossary helpful when you are working through the Units. It should come in particularly useful when you are answering assignment questions and revising for the final examination.

1 Every flagged term in the S102 texts has a Glossary entry, formulated at the level appropriate for the Science Foundation Course.

2 Each entry is normally concluded by a reference, in brackets, to the Unit (or Units) in which the term is flagged. These flagged entries are printed in bold in the index(es) of the Unit(s) in which the entry is flagged.

3 There are a few entries that do not correspond exactly to flagged terms. These entries, which are included for easy reference, are not concluded by a Unit reference.

A

ABBREVIATED STRUCTURAL FORMULA This is a simplified structural formula that shows explicitly only the connecting bonds that form the backbone of a molecule together with any bonds to functional groups (see structural formula). (Units 17–18)

ABSOLUTE DATING METHOD A method of determining the absolute age of a geological event. Most such methods involve the measurement of radioactive decay. (Units 28–29)

ABSORPTION SPECTRUM A spectrum containing dark lines indicating that electromagnetic radiation with particular frequencies is absorbed. The spectrum results from electron jumps or transitions from lower to higher energy levels. (Units 11–12)

ABYSSAL PLAIN The part of the ocean floor that lies between 4 and 6 km below the surface. Abyssal plains (with the exception of seamounts) generally have low relief, and they make up the major part of the ocean floor. (Units 7–8)

ACCELERATION The rate of change of velocity with time. To specify an acceleration completely, information must be given about both its magnitude and its direction. For an object moving in a straight line with constant acceleration,

$$|\text{acceleration}| = \frac{|\text{final speed} - \text{original speed}|}{\text{time taken for speed to change}}$$

The SI unit of (magnitude of) acceleration is m s^{-2} . See also orbital acceleration. (Unit 3)

ACCURATE MEASUREMENT A measurement in which the systematic errors are minimal (cf. precise measurement). (Unit 4)

ACETYL COENZYME A (ACETYL CoA) A metabolically active form of acetic acid that is formed when acetic acid reacts with a coenzyme called coenzyme A.

Acetyl CoA is the product of the link reaction and β -oxidation. (Unit 22)

ACHONDRITE A stony meteorite that has no chondrules. (Units 28–29)

ACHROMATIC TIME The time taken from the moment when amylase and starch solution are mixed to the moment when the mixture no longer gives a blue-black colour with iodine solution, i.e. the time taken for all the amylose molecules in the starch to be broken down. (Unit 22)

ACID A substance that dissolves in either pure water or an aqueous solution and yields aqueous hydrogen ions. If the hydrogen ion concentration is high enough, its solution has other characteristic properties, such as sourness and the capacity to turn blue litmus red. (Unit 15)

ACID DISSOCIATION CONSTANT, K_a The equilibrium constant for the dissociation of a weak acid. (Unit 15)

ACID RAIN Rainwater with a higher acidity (lower pH) than that caused by the dissolution of atmospheric carbon dioxide. An important cause of acid rain is the aerial oxidation of industrial pollutants such as SO_2 and NO to sulphuric and nitric acids, which subsequently dissolve in rainwater. (Unit 15)

ACID STRENGTH The extent to which an acid in aqueous solution is broken down into aqueous hydrogen ions and the accompanying aqueous anions. The acid dissociation constant is a measure of acid strength. (Unit 15)

ACQUIRED CHARACTERISTICS Characteristics that an organism gains during its lifetime by virtue of its own activities and/or exposure to particular features of its environment. (Unit 19)

ACTINIDES A set of 14 chemical elements, defined in this Course as the series of elements from Ac to No (numbers 89–102) inclusive. They are all radioactive, include uranium and plutonium, and occur in a region of atomic number where the 5f shell in the free atoms is being filled up. (Units 13–14)

ACTIVATED COMPLEX A concept that can be illustrated by a simple one-step gas reaction between two molecules. As the reaction proceeds, the energy of the reacting pair rises to a maximum and then drops gradually until the final products are generated. The activated complex is the molecular arrangement of the reacting pair when the energy is at a maximum. (Unit 16)

ACTIVATION ENERGY A concept that can be illustrated by a simple one-step gas reaction between two molecules. As the reaction proceeds, the energy of the reacting pair rises to a maximum and then drops gradually until the final products are generated. The activation energy is the energy difference between this

maximum energy and the energy of the reactants before the reaction began. In biology, enzymes catalyse reactions by lowering the activation energy. (Unit 16)

ACTIVE SITE The site on the surface of an enzyme molecule to which a substrate molecule binds, giving an enzyme-substrate complex. (Unit 22)

ACTIVE TRANSPORT Movement of ions or molecules across a membrane from a region of lower concentration to one of higher concentration—thus requiring the expenditure of energy. (Unit 22)

ADAPTATION The idea that some feature of an organism, such as a facet of its structure, is well suited to the function that the feature performs in the organism's life. (Unit 19)

ADDITION POLYMER A polymer formed from a monomer molecule containing a carbon-carbon double bond. The monomer polymerizes by a sequence of reactions in which the growing polymer molecule adds to the double bond of a further monomer molecule. (Units 17-18)

ADDITION REACTION A chemical reaction in which an unsaturated compound (containing, for example, a carbon-carbon double bond) reacts to form a saturated compound. (If the compound contains a triple bond, it is possible for an addition reaction to produce a compound containing a double bond.) (Units 17-18)

ADENINE (A) One of the five organic bases that are components of deoxyribonucleotides and ribonucleotides. It has a two-ring structure known as a purine ring system. (Unit 24)

ADENOSINE DIPHOSPHATE (ADP) See adenosine triphosphate. (Unit 22)

ADENOSINE TRIPHOSPHATE (ATP) This is formed from adenosine diphosphate (ADP) and inorganic phosphate (P_i). Conversely, ATP can be converted into ADP and P_i . About 30 kJ mol^{-1} are required to form ATP, and about 30 kJ mol^{-1} are made available when ADP and P_i are formed from ATP. This chemical energy is converted into other forms, such as the kinetic energy of muscles. ATP is therefore often referred to as an energy transducer. (Unit 22)

ADRENAL CORTEX The outer group of cells of the adrenal glands. (Unit 23)

ADRENAL GLANDS Small organs close to, or attached to the kidneys, in vertebrates. They secrete adrenalin. (Unit 23)

ADRENALIN A hormone, secreted by the adrenal glands. It has a stimulatory effect on many systems in the human body. (Unit 23)

AEROBIC CATABOLISM See aerobic respiration.

AEROBIC RESPIRATION The term—applicable to whole organisms, tissues or cells—refers to the cellular

reactions that bring about the complete oxidation of organic compounds, such as glucose, to carbon dioxide and water. Oxygen itself is required, hence the description 'aerobic'. Aerobic catabolism is the biochemistry of aerobic respiration. For glucose, aerobic catabolism occurs in four stages—glycolysis, the link reaction, the tricarboxylic acid cycle and the electron transport chain. It is in this last stage that the oxygen is consumed. Much more ATP is produced in aerobic respiration than in anaerobic respiration. (Unit 22)

AFTERSHOCKS Earthquakes that follow within days of a severe earthquake. Their magnitudes are usually lower than that of the main earthquake. (Units 5-6)

ALCOHOL A compound with molecules in which a hydroxyl group $-\text{OH}$, is attached to a hydrocarbon group. If the hydrocarbon group is saturated, the systematic name of a member of this class of compounds is alkanol. (Units 17-18)

ALCOHOL DEHYDROGENASE An enzyme involved in alcoholic fermentation in yeast and in alcohol detoxification in mammalian liver. (Unit 22)

ALDEHYDE A compound with molecules in which a formyl group, $-\text{CH}=\text{O}$, is attached to a hydrocarbon group. If the hydrocarbon group is saturated the systematic name of a member of this class of compounds is alkanal. (Units 17-18)

ALKALI An aqueous solution of hydroxide ions which, if sufficiently concentrated, has a greasy feel and bitter taste. The name is derived from the Arabic *al-galiy* (ash), because such solutions can be made by adding water to the ashes of wood or plants. Alkalis are thus solutions of bases that contain appreciable concentrations of hydroxide ions.

ALKALI METALS The metallic elements lithium, sodium, potassium, rubidium, caesium and francium, so named because the metals dissolve in water to give solutions that contain significant concentrations of aqueous hydroxide ions. Materials generating such solutions are said to be alkalis. The alkali metals occur in Group I of the Periodic Table. (Units 13-14)

ALKANAL See aldehyde. (Units 17-18)

ALKANAMINE See alkylamine (Units 17-18)

ALKANE A hydrocarbon in which each of the carbon atoms is attached to four other atoms. Such a compound is said to be saturated and has the general molecular formula $\text{C}_n\text{H}_{2n+2}$. (Units 17-18)

ALKANOL See alcohol. (Units 17-18)

ALKANONE See ketone. (Units 17-18)

ALKENE A hydrocarbon containing a double bond between two carbon atoms, each of which is attached to two other atoms. Such a compound is said to be unsaturated, and has the general molecular formula C_nH_{2n} . (Units 17-18)

ALKYLAMINE A compound with molecules in which an amino group, $-\text{NH}_2$, is attached to a hydrocarbon group. If the hydrocarbon group is saturated, the systematic name of a member of this class of compounds is alkanamine. (Units 17–18)

ALKYL GROUP A type of hydrocarbon group with one spare valency, which can be thought of as an alkane molecule from which one hydrogen atom has been removed. The simplest alkyl group is the methyl group, $-\text{CH}_3$; alkyl groups have the general formula $-\text{C}_n\text{H}_{2n+1}$. (Units 17–18)

ALKYNE A hydrocarbon containing a triple bond between two carbon atoms, each of which is attached to one other atom. Such a compound is said to be unsaturated, and has the general molecular formula $\text{C}_n\text{H}_{2n-2}$. (Units 17–18)

ALLELES The different versions of a gene that can occur at the locus occupied by that gene. Often there are just two versions, one frequently dominant over the other. Sometimes, however, there are several versions, only two of which can be present at any given time, e.g. in the genotypic determination of blood groups. (Unit 20)

ALLOY A metallic substance made by combining two or more chemical elements. The elements concerned are usually themselves metals. (Units 13–14 and 28–29)

α -DECAY The process in which a nucleus decays to form a less massive nucleus with the ejection of an α -particle, e.g. ${}^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^4_2\text{He}$. α -Decay is one of the types of radioactive decay. (Units 11–12 and 31)

α -PARTICLE The particle that is ejected in α -decay. An α -particle is a helium nucleus, which is represented as ${}^4_2\text{He}$ (or He^{2+} since it is a helium atom stripped of both its electrons). (Units 11–12)

ALVEOLI (singular alveolus) Small, air-filled sacs in the lung, surrounded by blood vessels. Each alveolus has thin walls, and it is through these walls that respiratory gases diffuse. (Unit 23)

AMIDE A compound with molecules containing an amide group, $-\text{C}(=\text{O})-\text{N}-$. (Units 17–18)

AMINO ACID A compound with molecules that contain both an amino group, $-\text{NH}_2$, and a carboxyl group, $-\text{C}(=\text{O})-\text{OH}$. A group of about 20 naturally

occurring amino acids is particularly important in living things; these have the general formula $\text{NH}_2-\text{CH}(\text{R})-\text{C}(=\text{O})-\text{OH}$, where R represents one of about

20 different groups. Amino acids are the monomers of polypeptides and proteins. (Units 17–18)

AMINO ACID RESIDUE A segment of a protein or polypeptide that corresponds to a single amino acid monomer. It has the general formula $-\text{NH}-\text{CH}(\text{R})-\text{C}(=\text{O})-$. (Units 17–18)

AMINO ACID-tRNA COMPLEX The name used to refer to tRNA when it is linked to a specific amino acid. (Unit 24)

AMINO GROUP A group with the formula $-\text{NH}_2$ that has one spare valency; it can be thought of as an ammonia molecule (NH_3) from which one hydrogen atom has been removed. Compounds containing an amino group have very similar properties to ammonia; in particular they are basic, that is they readily combine with hydrogen ions. (Units 17–18)

AMMONITE An invertebrate whose shell is coiled in a plane; the animal occupies the last chamber of the segmented shell. Especially abundant in the Mesozoic Era. (Units 28–29)

AMOUNT OF SUBSTANCE (chemistry) The number of moles of a substance that are present in a given sample. (Units 13–14)

AMPERE, A The SI unit of electric current, defined as a rate of flow of charge past a point of one coulomb per second: $1 \text{ A} = 1 \text{ C s}^{-1}$. (Unit 9)

AMPLITUDE OF A WAVE, A For a wave whose displacements are perpendicular to its direction of motion, its amplitude is the height of a crest of the wave above (or the depth of a trough below) the average height of the wave. Alternatively, it is half the vertical distance between the crests and troughs of the wave. (Units 5–6 and 10)

AMYLASE An enzyme that hydrolyses polymers of glucose containing α -1,4 glycosidic bonds. (Unit 22)

AMYLOPECTIN A highly branched polymer of glucose with α -1,4 glycosidic bonds in the sections between branches and α -1,6 bonds at the branch points. Starch is a mixture of amylopectin and another glucose polymer, amylose. (Unit 22)

AMYLOSE An unbranched polymer of glucose in which the glucose residues are linked by α -1,4 glycosidic bonds. Starch is a mixture of amylose and another glucose polymer, amylopectin. (Unit 22)

ANABOLISM The cellular synthesis of organic molecules from smaller molecules. Different substances are made by different anabolic (biosynthetic) pathways. All anabolic pathways are energy-requiring. Anabolism and catabolism together constitute metabolism. (Unit 22)

ANAEROBIC CATABOLISM See anaerobic respiration.

ANAEROBIC RESPIRATION The term—mainly applicable to cells, tissues or single-celled organisms—refers to the cellular reactions that bring about the partial catabolism of organic compounds in the absence of oxygen. Anaerobic catabolism is the biochemistry of anaerobic respiration. In anaerobic catabolism, the link reaction, the tricarboxylic acid cycle and the electron transport chain cannot occur. Yeast, respiring anaerobically, converts pyruvic acid (the end-product of glycolysis) into carbon dioxide and ethanol. Muscle tissue, respiring anaerobically, converts pyruvic acid into lactic acid. Much less ATP is produced in anaerobic respiration than in aerobic respiration. (Unit 22)

ANAPHASE See meiosis and mitosis.

ANDESITE A volcanic rock intermediate in composition between a basalt and a rhyolite, and characteristic of Andean-type (ocean/continent) destructive plate margins. Andesites are rich in silica, lower in density and generally lighter in colour than basalts. The average composition of continental crust is the same as that of andesite. (Units 7–8 and 27)

ANGLE OF INCIDENCE, i The angle between the path of an incoming (incident) wave and the normal. (Units 5–6)

ANGLE OF REFLECTION, R The angle between the path of a reflected wave and the normal; R is equal to the angle of incidence i . (Units 5–6)

ANGLE OF REFRACTION, r The angle between the departing (refracted) wave and the normal. (Units 5–6)

ANGULAR SIZE The angular size of an object, when viewed from a point, is determined by the angle subtended at that point by the object—the larger the angle, the larger the angular size. (Unit 2)

ANION A negatively charged ion. (Units 13–14)

ANTICODON The three-base sequence on a tRNA molecule that is complementary to a three-base sequence (a codon) on an mRNA molecule. (Unit 24)

ANTIPARTICLE An entity that has the same rest mass as the corresponding particle but that has the opposite values of other properties, such as charge, baryon number, strangeness, charm, topness and bottomness. The antiparticle that corresponds to a given fundamental particle is also fundamental. (Unit 32)

AORTA Main artery leaving the left ventricle of the heart. It carries fully oxygenated blood to the systemic circulation that supplies the tissues. (Unit 23)

APPARENT POLAR WANDERING The name given to the observation that the apparent positions of the magnetic poles appear to change progressively with time, when determined using palaeomagnetic inclinations from rocks of different ages from the same terrane. (When determined from rocks of the same age from one terrane, the apparent positions of the magnetic poles are clustered together.) (Units 5–6)

AQUEOUS SOLUTION A solution in which water is the solvent. (Units 13–14)

ARCHIMEDES' PRINCIPLE This states that the magnitude of the upwards buoyancy force that acts on an object floating in a liquid is equal to the magnitude of the weight of liquid displaced by the part of the object that is beneath the surface of the liquid. See also isostasy. (Units 7–8)

ARRHENIUS DEFINITIONS The definitions of an acid and a base proposed by Svante Arrhenius. According to these definitions, an acid yields hydrogen ions in aqueous solution, and a base yields hydroxide ions. (Unit 15)

ARTERIES Blood vessels with muscular walls that carry blood away from the heart. (Unit 23)

ARTERIOLES Small-diameter arteries that take blood to the capillaries. Changes in the diameter of the arterioles regulate blood flow through the capillaries. (Unit 23)

ASSIMILATION (biology) In general biological usage, the term refers to the absorption by heterotrophs of organic compounds from the external environment. These organic compounds are used to provide both precursor molecules for biosynthesis and molecules for catabolism, and hence for ATP production. (Unit 22)

In the context of production ecology, the term describes the energy content of material absorbed into the cells of consumers (heterotrophs). It is a fraction of the food consumed, the rest being excreted as faeces. Therefore, assimilation is equal to consumption minus energy content of faeces. (Unit 25)

ASTEROID The asteroids are small planetary bodies, occupying a range of orbits between those of Mars and of Jupiter. (Units 28–29)

ASTHENOSPHERE The part of the Earth's mantle that flows (i.e. behaves as a ductile solid) to accommodate isostatic readjustments of the lithosphere. (Units 7–8)

ATOM The smallest particle of an element that is characteristic of the element, consisting of a nucleus surrounded by a number of electrons. An atom is electrically neutral and has a diameter of about 5×10^{-10} m. (Units 11–12)

ATOMIC NUMBER, Z The number of protons within the nucleus of an atom, also equal to the number of electrons in the atom. Each chemical element has a uniquely characteristic atomic number. (Units 11–12 and 31)

ATOMIC SPECTRUM Lines seen in the emission or absorption spectrum of an atom. An atomic spectrum is produced when electrons in the atom make transitions between energy levels. (Units 11–12)

ATP See adenosine triphosphate. (Unit 22)

ATRIA (singular atrium) Thin-walled chambers of the heart that receive blood from veins and act as reservoirs for the ventricles. There are two atria in the mammalian heart, the left atrium and the right atrium, separated by a muscular membrane called the septum. The atria are also known as the auricles. Amphibian hearts have only one ventricle. (Unit 23)

AUTOTROPH An organism that obtains the carbon of its organic compounds in the form of carbon dioxide taken in from the environment. It then converts that carbon dioxide to organic compounds by an energy-requiring process involving chemical reduction. Plants and photosynthetic bacteria use solar energy: the process is called photosynthesis. A few species of autotrophic bacteria are non-photosynthetic. (Unit 22)

In production ecology, autotrophs are also called producers.

AVERAGE BOND ENERGY An energy quantity assigned to a chemical bond in a molecule, such that when the molecule is broken up into individual isolated atoms at 25°C and a pressure of 1 atmosphere, the enthalpy change is approximately equal to the sum of the bond energies. (Unit 16)

AVOGADRO'S CONSTANT, N_A The number of atoms of ^{12}C present in 12 g of that isotope: $N_A \approx 6.022 \times 10^{23} \text{ mol}^{-1}$. (Units 13–14)

AVOGADRO'S LAW Equal volumes of gases contain equal numbers of molecules, at the same temperature and pressure. (Units 13–14)

AXES OF A GRAPH The pair of reference lines, usually at right angles to each other, used to locate points on a graph. (Unit 2)

AXIALLY GEOCENTRIC DIPOLE A magnetic dipole field aligned along the Earth's axis of rotation and with the centre of the dipole coincident with the centre of the Earth. (Units 5–6)

AXIAL MODULUS, ψ The ratio that is a measure of the elastic behaviour of a rock when subject to compression. Specifically, ψ is the ratio of compressional stress to compressional strain. In SI units, axial modulus is measured in N m^{-2} . (Units 5–6)

AXIAL RIFT The steep-sided elongated valley along the centre of some oceanic ridges, formed by subsidence of the central part as the oceanic crust on either side moves away. (Units 7–8)

AXIS OF ROTATION OF AN OBJECT (sometimes called the object's axis of spin) A (normally imaginary) line around which an object rotates when it executes spin. (Unit 1)

AXIS OF SPIN OF AN OBJECT See axis of rotation of an object. (Unit 1)

B

BACTERIA See prokaryote.

BALANCED EQUATION An equation that represents the conversion of substances into other substances, and that is usually written with symbols representing atoms, nuclei, electrons, etc. The two sides of the equation balance in number of atoms of each kind and in electric charge. (Units 11–12)

BALANCED FORCES Two or more forces whose magnitudes and directions are such that the net force is zero. (Unit 3)

BALANCED POLYMORPHISM The polymorphism that exists within a population as a result of a balance between opposing selection forces. One example of balanced polymorphism is the balanced occurrence—in an area of endemic malaria—of the alleles Hb^S and Hb^A , and the associated sickle-cell phenotype and normal red blood cell phenotype. (Unit 21)

BANDED IRONSTONE FORMATION (BIF) A rock formed from alternating layers of chert and haematite. (Units 28–29)

BARYON A hadron that has baryon number one, $B = 1$. According to the simple quark model, each baryon consists of three quarks. (Unit 32)

BARYON NUMBER A property that characterizes each hadron and quark. The baryon number B of a meson is zero, whereas that of a baryon is one and that of an antibaryon is minus one. (The baryon number of each lepton and gauge boson is zero.) Baryon number is conserved in strong interactions (and in all other types of interaction). (Unit 32)

BASALT A fine-grained igneous rock, often dark in colour, formed as a result of the rapid cooling of basaltic magma extruded on the Earth's surface. (Basaltic magma is the liquid formed by partial melting of mantle peridotite.) On the floor of the oceans it forms basalt pillow lavas. Basalt can be 'frothy' because of gas bubbles contained in the lava, or quietly effusive. (Units 5–6)

Basaltic rocks consist principally of plagioclase feldspar and pyroxene. (Unit 27)

BASE (chemistry) A substance that dissolves in either pure water or an aqueous solution and yields aqueous hydroxide ions. If the hydroxide ion concentration is high enough, its solution has other characteristic properties, such as bitterness, a greasy feel, and the capacity to turn red litmus blue. (Unit 15)

BASE (biology) A general name, used in the context of nucleic acids, for those molecules that have purine and pyrimidine ring structures. Adenine and guanine are purine bases; thymine, cytosine and uracil are pyrimidine bases. In discussing the structure and function of nucleic acids, standard abbreviations for the bases are used; e.g. DNA contains A, G, C and T, whereas RNA contains A, G, C and U. (Unit 24)

BASE-PAIRING RULES Bases are paired according to precise rules, between complementary strands of DNA, between the coding strand of DNA and mRNA, and between an mRNA codon and the anticodon sequence of tRNA. These rules are that adenine pairs with thymine (or uracil in RNA molecules), and guanine pairs with cytosine; in symbols, A-T (or A-U), and G-C. Conversely, T (or U) pairs with A, and C pairs with G. (Unit 24)

BATHOLITH Very large elongated masses of plutonic igneous rock intruded into the continental part of ocean/continent destructive plate margins. (Units 7-8)

BED (Earth sciences) The smallest rock-based stratigraphic unit. It describes one rock type in a sedimentary sequence. (Units 28-29)

BEDDING PLANE A surface in a sedimentary rock that is parallel to the surface of deposition. (Units 28-29)

BEDLOAD The material that is bounced or rolled along the sea-bed, river bed or ground by moving water or by wind, being too heavy to remain in suspension. (Unit 27)

BEHAVIOURAL ISOLATION The separation of one part of a population from another as a consequence of differences in behaviour of the two (or more) groups. It often results in reproductive isolation. (Unit 21)

β -DECAY The radioactive decay of an atomic nucleus in which a β -particle is emitted. There are two types of β -decay: β^- -decay and β^+ -decay. (Units 11-12)

β^- -DECAY A radioactive process in which a nucleus decays to form the nucleus of a different element, with the ejection of an electron and an electron antineutrino, e.g. $^{12}_6\text{C} \rightarrow ^{12}_7\text{N} + {}^0_{-1}\text{e}^- + \bar{\nu}_e$. The decay occurs when a neutron in the original nucleus decays into a proton, an electron and an electron antineutrino: $n \rightarrow p + e^- + \bar{\nu}_e$. (Unit 31)

β^+ -DECAY A radioactive process in which a nucleus decays to form a nucleus of a different element, with the ejection of a positron and an electron neutrino, e.g. $^{11}_6\text{C} \rightarrow ^{11}_5\text{B} + {}^0_{+1}\text{e}^+ + \nu_e$. The decay occurs when a proton in the original nucleus decays into a neutron, a positron and an electron neutrino $p \rightarrow n + e^+ + \nu_e$. (Unit 31)

β -OXIDATION PATHWAY The mitochondrial pathway by which long-chain fatty acids such as stearic acid and palmitic acid are catabolized to many acetyl CoA molecules. (Unit 22)

β -PARTICLE A particle that is emitted in β -decay. In β^- -decay, a β^- -particle (an electron) is emitted, whereas in β^+ -decay, a β^+ -particle is emitted. (Units 11-12)

BIG BANG The event in which space, time, matter and energy are believed to have been created. It is currently believed that the Big Bang took place approximately 16 000 million years ago. (Unit 32)

BINDING ENERGY OF A NUCLEUS The minimum energy required to break apart a nucleus into its free constituents. (Unit 31)

BIOCHEMISTRY The branch of science concerned with the chemical events within living organisms, especially within cells. (Unit 22)

BIOGEOCHEMICAL CYCLES The global cycles of nutrient elements between living organisms and the non-living (geological) environment, i.e. soil, water, rocks and air. An example is the carbon cycle. (Unit 25)

BIOLOGICAL CONTROL The control of pests by biological agents, especially predators or parasites released into the pest population. (Unit 25)

BIOLOGY The study of living organisms. Biology includes the study of the structure and function of organisms, the way in which they interrelate with their environment, and their evolutionary history. (Unit 19)

BIOLUMINESCENCE The conversion of chemical energy into light energy in living organisms (e.g. fireflies and glow-worms). (Unit 22)

BIOMASS The dry mass of all organic compounds present in living organisms (or a particular type of organism, e.g. plants) in a given area (expressed in kg m^{-2} in SI units). Biomass is also expressed in terms of the amount of energy that would be released if that dry mass were completely oxidized (expressed in kJ m^{-2} in SI units). (Unit 25)

BIOPOLYMER A naturally occurring polymer. (Units 17-18)

BIOTIC COMMUNITY See community.

BIOSTRATIGRAPHIC COLUMN The array of zones that results from stacking them vertically with the oldest at the base overlain by successively younger zones. (Units 28-29)

BIOSYNTHESIS The cellular synthesis of organic molecules from smaller molecules. Different substances are made by different biosynthetic (anabolic) pathways. All biosynthetic pathways are energy-requiring. (Unit 22)

BIOTIC FACTORS Those environmental factors that are attributable to the influence of organisms (cf. physico-chemical factors). (Unit 25)

BIVALVE An invertebrate animal with a two-valved shell, e.g. mussel. Each shell is a mirror image of the other, but lacks individual symmetry. Common in the fossil record since the Mesozoic Era. (Units 28-29)

BLOOD CELLS See red cells, white cells.

BLUE-GREEN BACTERIA (formerly termed blue-green algae) A subkingdom of the prokaryote kingdom. Blue-green bacteria contain several photo-

synthetic pigments and reproduce not by sexual means but by simple division. (Units 28–29)

BODY CELLS See somatic cells.

BOND See chemical bonding.

BOND DISSOCIATION ENERGY The energy that must be transferred to a molecule at some fixed temperature (typically 25 °C) in order to break or dissociate the molecule into two fragments. The bond in question is the one that links the two fragments in the complete molecule. (Unit 16)

BOTTOMNESS A property, generally denoted by B , that characterizes each hadron and quark (the bottomness of every lepton and gauge boson is zero). Bottomness is conserved in strong interactions (and in electromagnetic interactions, but not in weak interactions). (Unit 32)

BOULDER CLAY See till. (Units 7–8)

BOUND STATE The state of an atom in which the electron(s) is (are) bound in an energy level, not in the continuum. (Units 11–12)

BRACHIOPOD An invertebrate animal with a two-valved shell, each shell being bilaterally symmetrical. Chiefly found in the Palaeozoic Era. (Units 28–29)

BRITTLE DEFORMATION OF ROCKS The response of rocks to deformation by snapping or rupturing. (Unit 27)

BUBBLE CHAMBER A device that enables the tracks of charged particles to be observed. The chamber contains a pressurized liquid (normally hydrogen), and when charged particles pass through it they can ionize the atoms with which they collide. Streams of tiny bubbles are consequently left in the liquid and these bubbles are illuminated and photographed to show the paths of the particles. (Unit 30)

C

CALCITE A crystalline form of calcium carbonate (CaCO_3). It has three cleavages at about 60° (or 120°) to each other. The shells of many marine organisms are composed of calcite, and the remains of these may accumulate on the sea floor and eventually may form limestone. (Unit 27)

CALDERA An approximately circular collapse structure often found above the main vent of a volcano, caused by the emptying of the magma chamber at depth after the last phase of an eruption. (Units 7–8)

CALIBRATION The process of checking one measuring instrument against another, more accurate one. (Unit 4)

CALVIN CYCLE The reactions of the dark stage of photosynthesis whereby carbon dioxide is converted (by chemical reduction) into carbohydrate. (Unit 22)

CAPILLARIES (biology) Small-diameter blood vessels that form a network between arteries (via arterioles) and veins in all tissues. Their walls are just one cell thick and they contain no muscle. Many capillaries are present in regions where a high rate of diffusion (e.g. lung) or heat exchange (e.g. skin) occurs. (Unit 23)

CARBOHYDRATE Collective term for sugars and polysaccharides. (Unit 22)

CARBONACEOUS CHONDRITE A chondrule-bearing stony meteorite that contains carbon. (Units 28–29)

CARBON CYCLE The route taken by the element carbon in its cyclical movement between living organisms and the non-living environment. (Unit 25)

CARBON DATING A method of dating a sample that contains carbon, by estimating the relative amount of ^{14}C (to ^{12}C). The method uses either the counting of ejected β^- -particles or mass spectrometry. Its main uses are in archaeology and studies of relatively recent geological events, where it can give the age of wood, shell, bone and other forms of organic material. (Units 11–12)

CARBONIC ANHYDRASE An enzyme in red blood cells that catalyses the reversible reaction by which bicarbonate (hydrogen carbonate) ions and hydrogen ions are formed from carbon dioxide and water. (Units 22 and 23)

CARBONYL GROUP A group with the formula —C— that has two spare valencies. (Units 17–18)

$$\begin{array}{c} \text{O} \\ | \\ \text{—C—} \end{array}$$

CARBOXYL GROUP A group with the formula —C—OH that has one spare valency. It is acidic and readily loses a hydrogen ion to give a carboxylate anion, —C—O^- . (Units 17–18)

$$\begin{array}{c} \text{O} \\ | \\ \text{—C—OH} \\ | \\ \text{O} \end{array}$$

CARBOXYLIC ACID A compound with molecules of the general formula R—C—OH , where R is any group

$$\begin{array}{c} \text{O} \\ | \\ \text{R—C—OH} \end{array}$$

with one spare valency. In the homologous series of carboxylic acids, R is an alkyl group. (Units 17–18)

CARDIAC OUTPUT Blood flow provided by the heart. Cardiac output is equal to stroke volume multiplied by heart rate. (Unit 23)

CARNIVORE See first carnivore and higher carnivore.

CATABOLISM The breaking-down of a molecule into smaller molecules, usually involving the production of

ATP. Catabolism may be aerobic (involving oxygen) or anaerobic (not involving oxygen). There are many different aerobic catabolic pathways but these all lead into the central (catabolic) pathways. Catabolism and anabolism together constitute metabolism. (Unit 22)

CATALYST A substance that speeds up a chemical reaction, usually without being consumed itself. In living organisms, all enzymes are catalysts. (Unit 16)

CATASTROPHIC-EVENT THEORY A theory for the origin of the Solar System. It states that the close approach of a condensed star to the Sun resulted in a filament of gaseous material being extracted from the Sun by gravitational attraction, and that this filament subsequently condensed to form the planets (cf. nebular theory). (Units 28–29)

CATASTROPHISM A hypothesis stating that geological events result from a series of catastrophes. (Units 28–29)

CATENATION The linking together of atoms to form chains. Carbon is unique in being the only element that can catenate (link together) apparently without limit. (Units 17–18)

CATION A positively charged ion. (Units 13–14)

CELL The basic unit out of which animals and plants are mainly built. (Unit 19)

CELL-FREE SYSTEM A biochemically active system of cellular components. An example is a system containing all the requirements for protein synthesis. (Unit 24)

CELLULASE An enzyme that hydrolyses polymers of glucose containing β -1,4 glycosidic bonds, e.g. cellulose. This enzyme is absent in humans but is found (for example) in snails and in the bacteria that inhabit the guts of ruminants, e.g. cows. (Unit 22)

CELLULOSE An unbranched polymer of glucose in which the glucose residues are linked by β -1,4 glycosidic bonds. Cellulose is the major structural polysaccharide of plant cell walls. (Unit 22)

CEMENT (Earth sciences) The fine particles holding together fragmental grains in sedimentary rocks. (Units 5–6)

CENTRAL PATHWAYS A term meaning those parts of glucose catabolism that are also involved in the catabolism of other substances, namely glycolysis, the link reaction and the tricarboxylic acid cycle. (Unit 22)

CENTRIFUGE A piece of equipment used to separate particles differing in size, shape or density, by spinning a suspension of the particles in centrifuge tubes. Centrifuges are used routinely in biochemistry laboratories to separate the components of cells. (Unit 22)

CENTROMERE The point on a chromosome at which the chromatids are held together. (Unit 20)

CEREBRAL CORTEX Area of the mammalian brain. Among other functions, it is responsible for the voluntary control of breathing. (Unit 23)

CEREBROSPINAL FLUID (CSF) The fluid that fills the cavity inside the mammalian brain and spinal cord. Between the CSF and the blood there is a barrier across which small molecules such as dissolved gases can pass, but blood cells or large proteins cannot. (Unit 23)

CHARGE A property of some objects that is responsible for electrostatic and magnetic interactions between them. The SI unit of charge is the coulomb, C. Charge occurs in two forms: positive and negative. Like charges have a repulsive electrostatic interaction, unlike charges an attractive electrostatic interaction. The natural unit of charge is the magnitude e of the charge of an electron, where $e \approx 1.602 \times 10^{-19}$ C. (Unit 9)

CHARM A property, generally denoted by C , that characterizes each hadron and quark. (The charm of every lepton and gauge boson is zero.) Charm is conserved in strong interactions (and in electromagnetic interactions but not in weak interactions). (Unit 32)

CHEMICAL BONDING The concept that describes the means by which atoms or ions stick together in chemical compounds. We distinguish different types of chemical bond according to the nature of the interaction between the atoms or ions. Atoms in molecules are held together by covalent bonds. Ions in crystals are held together by ionic bonds. Weaker types of bonding (e.g. hydrogen bonds) also occur. (Units 17–18)

CHEMICAL COMPOSITION The composition of a substance expressed in terms of the amounts of the different chemical elements that the substance contains. (Units 13–14)

CHEMICAL COMPOUND A substance that consists of more than one element, the atoms being bound together in a fixed ratio that is characteristic of the substance. (Units 13–14)

CHEMICAL ELEMENT A substance that consists of atoms that each have the same atomic number. (Units 11–12)

CHEMICAL ENERGY The form of energy that changes in a chemical reaction; for example, when natural gas burns, chemical energy is transformed into heat. (Unit 9)

CHEMICAL EQUATION A statement using chemical symbols to represent the conversion of reactants into products in a chemical reaction. The equation must be balanced: the same numbers of atoms of each kind and the same electric charge must be present on each side of the equation. (Units 13–14)

CHEMICAL EQUILIBRIUM A chemical system at a constant temperature that has a static appearance because of two opposed chemical processes proceeding at equal rates. (Unit 15)

CHEMICAL EVOLUTION The hypothesis that the evolution of life on Earth was preceded by the formation of the necessary precursor organic compounds from small inorganic molecules, which then led inevitably to the appearance of life. (Units 17–18)

CHEMICAL FORMULA A representation of a chemical substance using chemical symbols to denote the constituent atoms, with subscripts to indicate the relative numbers of atoms of each type. For example, water is represented by the formula H_2O . (Units 13–14)

CHEMICAL REACTION A process in which a substance (or substances) is transformed to a different substance (or substances) by an intimate rearrangement of the atoms and their accompanying electrons. During the reaction, the individual atomic nuclei and the electrons are preserved. (Units 13–14)

CHEMICAL STRUCTURE The arrangement in space of the atoms or ions that constitute a substance. (Units 13–14)

CHEMICAL SYMBOL The letters used to symbolize a chemical element, or an atom of the element; for example, O for oxygen, Cu for copper. (Units 11–12)

CHEMICAL WEATHERING The breakdown of rocks by chemical action; for example, limestones are dissolved by rainwater containing carbon dioxide. (Unit 27)

CHEMISTRY The branch of science concerned with the composition, properties and reactions of substances. (Units 11–12)

CHEMORECEPTORS Receptors that respond to chemical stimuli. (Unit 23)

CHERT A fine-grained siliceous rock formed by the biochemical precipitation of amorphous silica. (Units 28–29)

CHIASMA (plural **CHIASMATA**) The region of a pair of homologous chromosomes at which chromatids cross over during meiosis. (Unit 20)

CHILLED MARGIN The fine-grained edge of an intrusive igneous body, which becomes cooled (chilled) by the rocks into which it is intruded and so crystallizes more quickly. (Unit 27)

CHIRAL CENTRE A carbon atom connected to four different groups or atoms; this results in the molecule being chiral or 'handed'. (Units 17–18)

CHIRALITY The property of 'handedness' such that an object and its mirror image cannot be exactly superimposed, one on the other (like a left hand and a right hand). Applied to molecules, a molecule is said to be chiral if it has a structure such that a model of that molecule and a model of its mirror image cannot be superimposed. (Units 17–18)

CHLOROPLASTS The organelles in plant cells in which photosynthesis occurs. The layers of membranes within a chloroplast contain chlorophyll and are the site of the light stage of photosynthesis. The liquid between the membranes contains the enzymes responsible for the dark stage of photosynthesis. (Unit 22)

CHONDRITE A stony meteorite that contains chondrules. (Units 28–29)

CHONDRITIC EARTH MODEL A model for the formation of the Earth. It postulates that the Earth was initially homogeneous and similar to chondrites in composition, and later segregated into its constituent layers. (Units 28–29)

CHONDRULES Small globular mineral aggregates found in certain stony meteorites known as chondrites. (Units 28–29)

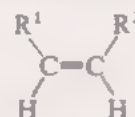
CHROMATID Before meiosis or mitosis, a chromosome is split along its length into two identical halves, each of which is called a chromatid. (Unit 20)

CHROMATIN The DNA plus protein combination that makes up the material of chromosomes. (Unit 20)

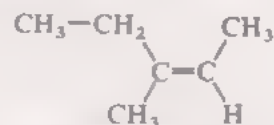
CHROMOSOMES Structures inside the nucleus, made partially of DNA, that carry the hereditary information of the cell. (Unit 19)

More precisely, they are thread-like structures inside the nucleus of eukaryotic cells, containing DNA and other substances, that constitute the cell's genetic material. Note, however, that prokaryotic cells (bacteria) each contain just *one* chromosome and that this is *not* contained within a nucleus. (Unit 20)

cis ISOMER A molecule containing a carbon-carbon double bond with the following stereochemistry:



where R^1 and R^2 are two groups (or atoms neither of which is hydrogen) that can be the same or different. For compounds such as 3-methylpent-3-ene (shown below), it is the relationship of the larger of the groups at each end that determines which isomer is called *cis*. (See also *trans* isomer.)



cis-3-methylpent-3-ene

(Units 17–18)

CITRIC ACID A C_6 intermediate in the tricarboxylic acid cycle. Citric acid is formed when oxaloacetic acid (a C_4 intermediate of the cycle) reacts with acetic acid (C_2) in the form of acetyl CoA. (Unit 22)

CLASS (biology) Part of the taxonomic hierarchy. Several orders are gathered into one class and several classes form a phylum. (Unit 21)

CLASS OF (ORGANIC) COMPOUNDS A series of compounds with molecules that contain the same functional group; for example, the alcohols all contain a hydroxyl group —OH , and so constitute a class. Members of a class do not necessarily belong to the same homologous series because the rest of the molecule may differ greatly in one member compared with another. (Units 17–18)

CLASSICAL (or NEWTONIAN) MECHANICS The branch of physics based on Newton's laws and dealing with the motion of matter. (Unit 3)

CLAY MINERALS Various types of hydrated minerals occurring as extremely small flakes, usually resulting from the breakdown of other minerals, such as feldspars. (Unit 27)

CLEAVAGE The capacity of a mineral or rock to split along certain planes. A mineral can have several cleavage directions at angles to each other. Cleavage in minerals is a manifestation of planes of weakness within the internal atomic structure of the mineral. Mica, for example, has one perfect (very well defined) cleavage, whereas calcite has three, inclined at about 60° or 120° to each other. Cleavage in rocks is the tendency of a rock to split along parallel planes and results from the alignment of platy minerals such as micas. It is commonly seen in metamorphic rocks such as slate and phyllite. (Unit 27)

CLIMAX COMMUNITY A relatively stable community that is achieved at the end of an ecological succession. (Unit 25)

CODING DNA In genes, the strand of the DNA double helix that is transcribed into RNA is called the coding strand. (Unit 24)

CODON Each codon is a specific sequence of three bases coding for a particular amino acid. The sequence of codons therefore determines the sequence of amino acids. For example, the amino acid valine can be coded on the DNA by the base sequence CAT. This gives the base sequence GUA on the mRNA. A tRNA molecule with the anticodon sequence CAU will bind to the mRNA at the sequence GUA (see base-pairing rules), and thus introduce valine into the correct position for incorporation into a polypeptide chain. (Unit 24)

COENZYME A A coenzyme involved in the metabolically active form of acetic acid (acetyl coenzyme A). It is also involved with other fatty acids. (Unit 22)

COENZYMES Coenzymes are small organic molecules that work with some enzymes in certain reactions. Examples include NAD, NADP, FAD and coenzyme A, all of which have important roles in metabolism. The B-group vitamins are involved in coenzyme structure, for example riboflavin in FAD (Unit 22)

COLLIDING BEAM EXPERIMENT An experiment in which a beam of particles is made to collide head-on (or nearly head-on) with another beam of particles. (Unit 32)

COLLISION MODEL OF A CHEMICAL REACTION A model of a chemical reaction between molecules, according to which the rate of the reaction depends on the frequency with which the molecules collide. (Unit 16)

COLOR-METER Instrument used to measure the amount of light that will pass through a solution. It can be used for comparative measurements of concentration if the colour of samples varies in a predictable manner. (Unit 23)

COMBUSTION REACTION A chemical reaction in which a substance reacts with a gas such as oxygen or fluorine, and produces both heat and light, usually in the form of a flame. (Unit 16)

COMMUNITY The collection of organisms (of various species of animal and plant groups) that live together in a particular habitat. Also called biotic community. (Unit 25)

COMPETITION (biology) The word Darwin used to describe the hypothesis that organisms with certain phenotypes would increase over successive generations at the expense of organisms lacking those phenotypes. (Unit 19)

COMPLEMENTARY BASES In DNA, adenine pairs with thymine, and cytosine with guanine. In RNA, adenine pairs with uracil, and cytosine with guanine. (Unit 24)

COMPONENTS OF MOMENTUM Quantities (with the SI unit of kg m s^{-1}) that specify the momentum of a particle with respect to a fixed set of axes. For motion in three dimensions, the momentum of a particle of mass m can be specified by the values of three momentum components p_x , p_y , and p_z , where $p_x = mv_x$, $p_y = mv_y$, and $p_z = mv_z$, where v_x , v_y and v_z are the particle's components of velocity. (Unit 30)

COMPONENTS OF POSITION Quantities (with the SI unit of m) that specify the position of a particle with respect to a fixed set of axes. In three dimensions, the position of a particle can be specified by the values of three position components x , y , and z . (Unit 30)

COMPONENTS OF VELOCITY Quantities (with the SI unit of m s^{-1}) that specify the velocity of a particle with respect to a fixed set of axes. For motion in three dimensions, the velocity of a particle can be specified by the values of three velocity components v_x , v_y and v_z . (Unit 30)

COMPOSITE CONES Volcanic cones built up of alternate lavas and pyroclastic deposits. (Unit 27)

COMPOUND See chemical compound.

COMPRESSIONAL WAVE MOTION The type of wave motion in which there is a change in the volume of a block of material through which the wave passes, but no change in the overall rectangular shape. (Units 5–6)

COMPRESSION PULSE The cycle of compression (followed by a dilatation or rarefaction) in a medium subjected to the application of a force. (Units 5–6)

COMPTON EFFECT The scattering of a photon by an electron. Experiments on the Compton effect show that each quantum of electromagnetic radiation has both energy and momentum. (Units 10 and 30)

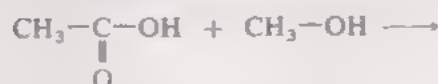
CONCENTRATION GRADIENT (biology) Occurs when the concentration of a substance varies from one part of a solution to another. Usually, a membrane separates the different regions. Energy must be expended when molecules or ions are moved from a region of lower concentration to a region of higher concentration, i.e. against the concentration gradient. (See active transport.) (Unit 22)

The difference between the concentrations at two points, divided by the distance between the points, gives a quantitative measure of concentration gradient. (Unit 23)

CONCENTRATION OF A SOLUTION A property of a solution that tells us the relative amounts of solute and solvent. Chemists usually express it as a molarity: the number of moles of solute in one litre of the solution. (Unit 15)

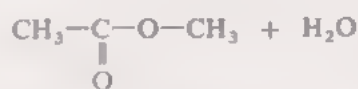
CONDENSATION POLYMER A polymer that is formed by the linking of monomer molecules by means of a condensation reaction. Most biopolymers are condensation polymers. (Units 17–18)

CONDENSATION REACTION The reaction of two molecules to form a bond between them, usually with the simultaneous expulsion of a small molecule such as water (H_2O), ammonia (NH_3), or hydrogen chloride (HCl). An example is the reaction between a carboxylic acid (e.g. acetic acid) and an alcohol (e.g. methanol) to form an ester:



a carboxylic
acid
(acetic acid)

an alcohol
(methanol)



an ester
(methyl acetate)

water

(Units 17–18)

CONFIGURATION (chemistry) The particular three-dimensional arrangement of a group of atoms about a central atom (usually a carbon atom) to which they are connected. (The configuration in this context

refers to an arrangement of atoms and hence is different from electronic configuration.) (Units 17–18)

CONFORMATION Free rotation of one end relative to the other is possible about a carbon–carbon single bond. The different relative arrangements are called conformations. The various possible conformations of a molecule readily interconvert and cannot usually be isolated. (Units 17–18)

CONSERVATION OF ELEMENTS (LAW OF) This states that elements are neither created nor destroyed in chemical reactions. This law distinguishes chemical reactions from nuclear reactions. (Units 13–14)

CONSERVATION OF ENERGY (LAW OF) This states that the total amount of energy in a physical system is always constant (i.e. energy cannot be created or destroyed), although some or all of the energy may be converted from one form into another. (Unit 9)

CONSERVATION OF MASS (LAW OF) This states that mass is conserved in a chemical reaction: the mass of the reactants is equal to the mass of the products. (Units 13–14)

CONSERVATION OF MOMENTUM (LAW OF) This states that the total momentum of any group of objects is constant, provided they are not subjected to unbalanced external forces. (Unit 3)

CONSERVATIVE PLATE MARGIN A boundary between two lithospheric plates at which crust is neither created nor destroyed. Conservative plate margins are the active parts of transform faults. (Units 7–8)

CONSERVED QUANTITY A physical quantity, such as momentum or energy, that in an isolated system is quantitatively unchanged with time. (Unit 3)

CONSTANT OF PROPORTIONALITY A constant equal to the ratio of two quantities that are proportional to each other. For example, if y is proportional to x , (i.e. $y \propto x$), we can write $y = kx$, where k is the constant of proportionality. (Unit 2)

CONSTELLATION A named grouping of stars in a region of the night sky. Examples are The Plough and Orion. (Unit 1)

CONSTRUCTIVE INTERFERENCE See constructive superposition. (Unit 10)

CONSTRUCTIVE PLATE MARGIN A boundary between two lithospheric plates at which crust is generated. Constructive plate margins are ocean ridges, so the new crust is always oceanic in character (Units 7–8)

CONSTRUCTIVE SUPERPOSITION (constructive interference) When two waves of equal wavelength are superposed in phase, they give rise to constructive superposition in which the resultant amplitude is, at all times, equal to the sum of the two component amplitudes. (Unit 10)

CONSUMER See heterotroph.

CONSUMPTION The total amount of energy taken in by consumers in a given area over unit time (usually expressed in $\text{kJ m}^{-2} \text{yr}^{-1}$). (Unit 25)

CONTACT METAMORPHISM A change in the mineralogy or texture of a rock as a result of heating from an igneous body. In contrast to regional metamorphism, platy minerals are not aligned. (Units 27 and 28–29)

CONTINENTAL CRUST The part of the Earth's crust that lies beneath the continents and the adjoining continental shelves at the edges of the oceans. It is 25–90 km thick (average 35 km), and has an average composition between granite and gabbro. (Units 5–6)

CONTINENTAL DRIFT THEORY The theory, first proposed in the 1850s and finally generally accepted in the 1960s, that the continents move around over the surface of the Earth, apparently independently. (Units 5–6 and 7–8)

CONTINENTAL RISE The area of the ocean floor that marks the transition between the continental slopes and the abyssal plains. The average gradient of the continental rises is about half a degree, and they are several hundreds of kilometres wide. (Units 7–8)

CONTINENTAL SHELF The area of the ocean floor bordering the continental land masses at a depth of 200 m or less below the sea surface. The shelf has an average gradient of about a tenth of a degree. (Units 7–8)

CONTINENTAL SLOPE The area of the ocean floor extending from the edge of the continental shelf to the start of the continental rise. The slope has an average gradient of about four degrees. (Units 7–8)

CONTINUOUS REFRACTION The smooth wave path produced when refraction occurs through a medium in which wave speed changes continuously with depth (as occurs within many of the Earth's layers). (Units 5–6)

CONTINUOUS SPECTRUM A spectrum that has a continuous range of frequencies of electromagnetic radiation, for example the white light spectrum is continuous in the visible region from red to violet. (Units 11–12)

CONTINUUM That part of an energy-level diagram where the energy varies continuously. An electron that has energy in the continuum is not bound to the atom: its energy is not quantized (Units 11–12)

CONTINUUM LEVEL The energy level of an electron that has escaped from an atom and which has zero kinetic energy. When an electron escapes from an atom, the atom is said to be ionized. (Units 11–12)

CONTROL GENES Sequences of DNA bases that have a controlling function over the expression of structural genes (via protein synthesis). (Unit 24)

CONTROL GROUP In an experiment, a group to which no special treatment is given. The behaviour of the control group is compared with that of the test group. (Unit 4)

CONVERGENCE The phenomenon whereby organisms with different basic morphologies share superficial similarities in features that relate to a common way of life. (Unit 19)

CONVEX LENS A piece of glass (or other transparent material) shaped so that its surfaces curve outwards (i.e. the lens is thicker at the centre than it is at the edges). It can make incident parallel light converge at a point beyond the lens. (Unit 10)

COPOLYMER A type of polymer formed by the polymerization of a small number (usually two or three) of different types of monomer. (Units 17–18)

CORAL Sedentary animal which secretes a preservable external skeleton that is composed of crystalline calcium carbonate. Some species live as solitary individuals, but many live in colonies where the external skeletons are joined together, making up a massive continuous structure (reef). (Units 28–29)

CORE The part of the Earth's interior that lies below the major solid-liquid boundary (with the solid above and the liquid below), which forms a major seismic discontinuity at a depth of 2900 km. (Units 5–6)

CORRELATION (Earth sciences) The recognition of some widespread past event in the sedimentary record enabling the times of deposition of sediments from different localities to be equated. (Units 28–29)

CORTEX See adrenal cortex and cerebral cortex.

COSINE (COS) In a right-angled triangle, the cosine of the angle θ (written as $\cos \theta$) is given by the length of the shorter side adjacent to the angle θ divided by the length of the hypotenuse. (Unit 2)

COSMIC RAYS High-energy particles (mostly protons) that originated in distant parts of the Universe, probably in the explosions of stars. (Unit 32)

COULOMB, C The SI unit of charge. (Unit 9)

COULOMB'S LAW The law describing the electrostatic interaction between stationary, point-like charges. If two such charges, of magnitude Q_1 and Q_2 , are separated by a distance r , they attract or repel each other with a force of magnitude AQ_1Q_2/r^2 , where A is a constant. The direction of the force is along the line joining the charges. Like charges repel and unlike charges attract. (Unit 9)

COVALENT BONDING A type of chemical bonding, in which the chemical bonds are represented by electron pairs shared between atoms. (Units 13–14)

CRATON An old, stable region of continental crust, characterized by low heat flow and the absence of volcanic or seismic activity. (Units 7–8)

CREEP (IN ROCKS) The gradual plastic deformation of a rock as a result of continuous stress. (Unit 27)

CREST OF A WAVE A position of maximum displacement of a wave, relative to the wave's average height, in a particular direction at right angles to the direction of propagation. A position of maximum displacement in the opposite direction is called a trough. (Unit 10)

CRINOID Radially symmetric reef-building fossil, with a cup and arms on a stem, common in the Palaeozoic Era. (Units 28–29)

CRITICAL ANGLE OF INCIDENCE The angle of incidence of a wave at a boundary between two media in which it has different speeds, for which the angle of refraction is 90°. At larger angles of incidence, there is no refraction at the boundary but there is total reflection. (Units 5–6)

CROSS-FERTILIZATION The fusion of a male gamete from one plant or animal with a female gamete from another plant or animal of the same species. (Unit 20)

CROSSING OVER The process that occurs during meiosis whereby bits of chromatids are exchanged between homologous chromosomes. (Unit 20)

CRUST The outer skin of the Earth; it varies in thickness from 6 km to about 90 km. See continental crust and oceanic crust. (Units 5–6)

CRYSTALLINE TEXTURE The texture of rock formed by the crystallization of magma, producing an interlocking mosaic of crystals. It is characteristic of igneous rocks such as granite and gabbro. (Units 5–6)

CRYSTALLITE A small region of solid polymer, where the molecules or segments of molecules are arranged in a regular manner akin to the regular pattern of molecules in a crystalline solid. (Units 17–18)

C-TERMINAL AMINO ACID Term frequently used interchangeably with C-terminal residue. (Unit 24)

C-TERMINAL RESIDUE In peptides, polypeptides and proteins the amino groups and carboxyl groups of the constituent amino acids are condensed together as peptide bonds, except at each end. At one end there is a free amino group and at the other a free carboxyl group. The two amino acid residues involved are, respectively, the N-terminal residue and C-terminal residue. The C-terminal residue, conventionally drawn at the right-hand end of the chain, has a free —C—OH group. (Unit 22)



CULMINATION POINT The culmination point for a given observer, on a given day, is the highest point above the horizon reached by the Sun. The Sun reaches this point approximately half-way through the daylight period. (Unit 1)

CUMULATES Rocks formed early in the crystallization of plutons by the accumulation of dense minerals, such as olivine, from the crystallizing melt. (Unit 27)

CURIE TEMPERATURE The temperature above which a magnetic material loses its magnetism; magnetism is restored if the material is cooled below its Curie temperature in a magnetic field. (Units 5–6)

CURRENT LOOP Loop of wire through which an electric current flows, resulting in a dipolar magnetic field. (Units 5–6)

CYCLICAL REGENERATION The process of re-establishment by organisms (for example, trees in a forest) when a localized patch of the habitat becomes vacant. (Unit 25)

CYTOCHROMES Iron-containing proteins that are carriers of electrons in the electron transport chain. The iron atom within each cytochrome molecule becomes alternately oxidized to iron(III) and reduced to iron(II) by (respectively) the loss or gain of an electron. The cytochrome at the end of the chain (cytochrome a) is directly involved in the reduction of oxygen to water. (Unit 22)

CYTOLOGY The study of cell structure. (Unit 20)

CYTOPLASM The term used for the cytosol together with everything else inside the cell except the nucleus. Sometimes, however, the term is used interchangeably with cytosol. (Unit 24)

CYTOSINE (C) One of the five organic bases that are components of deoxyribonucleotides and ribonucleotides. It has a one-ring structure known as a pyrimidine ring. (Unit 24)

CYTOSOL The fluid surrounding the organelles in a cell. See also cytoplasm. (Unit 19)

D

DARK STAGE OF PHOTOSYNTHESIS The stage of photosynthesis concerned with the conversion of carbon dioxide into carbohydrate. It occurs in solution in chloroplasts through a cyclic sequence of enzyme-catalysed reactions. NADPH₂ and ATP are required, and these are produced in the light stage. The dark stage is also called the Calvin cycle. (Unit 22)

DARWIN'S THEORY OF EVOLUTION BY NATURAL SELECTION The theory of evolution proposed by Charles Darwin, which postulates that present-day species have evolved from ancestral types

by the process of natural selection acting on organisms of differing fitnesses in a population. (Unit 19)

DAUGHTER DOUBLE HELICES New helices formed as a result of DNA replication. Each new helix is formed from one existing strand of DNA and one newly synthesized strand. (Unit 24)

DAUGHTER ISOTOPE An isotope that results from radioactive decay of a parent isotope. (Units 28–29)

DEAMINATION The removal of the amino group from an amino acid. Deamination is the first stage in amino acid catabolism. (Unit 22)

DE BROGLIE'S FORMULA The de Broglie wavelength λ_{dB} of a free quantum that has a momentum of magnitude p is given by $\lambda_{dB} = h/p$, where h is Planck's constant. (Unit 30)

DECOMPOSER Micro-organism (e.g. bacterium or fungus) that uses dead organic matter as a source of food and, as it breaks the food down, releases inorganic molecules or ions from organic molecules. Decomposers are heterotrophs. (Unit 25)

DEGENERACY The existence of energy levels that have the same energy. Electrons in the various degenerate energy levels are, however, characterized by different quantum numbers. (Units 11–12 and 31)

DEGENERATE CODE A term used in relation to the genetic code, to indicate that more than one codon specifies a particular amino acid. (Unit 24)

DEHYDROGENATION A reaction in which a substance is oxidized by the removal of a pair of hydrogen atoms. (Unit 22)

DENITRIFICATION The process in which bacteria convert nitrate into molecular nitrogen and oxides of nitrogen. It occurs only in anaerobic conditions. (Unit 25)

DENSITY The mass of a substance per unit volume. For an object with uniform density, density = mass/volume. The SI unit of density is kg m^{-3} . (Unit 3)

DENSITY-DEPENDENT MORTALITY RATE A mortality rate that increases when the density of the population on which the mortality acts increases. (Unit 25)

DENSITY GRADIENT CENTRIFUGATION A technique for the centrifugal separation of molecules that have a similar relative molecular mass but a different density. (Unit 24)

DENSITY INDEPENDENT MORTALITY RATE A mortality rate that is not affected by changes in the density of the population on which the mortality acts. (Unit 25)

DENUDATION The combined processes of weathering and erosion that gradually wear down mountainous landscapes. (Unit 27)

DEOXYRIBONUCLEIC ACID See DNA. (Unit 24)

DEOXYRIBONUCLEOTIDES The chemical units (monomers) that are polymerized to form DNA. Each has three parts: a sugar (deoxyribose), a phosphate group, and a base. Since there are four different bases (adenine, guanine, cytosine and thymine) there are four different deoxyribonucleotides. When the context permits they are simply referred to as 'nucleotides'. (Unit 24)

DEOXYRIBOSE A sugar molecule, containing five carbon atoms, involved in the structure of deoxyribonucleotides and hence of DNA. (Unit 24)

DEPENDENT VARIABLE In an experiment (or calculation), the quantity whose value is monitored for particular values of the independent variable set by the experimenter. On graphs, it is conventionally plotted along the vertical axis. (Unit 4)

DESTRUCTIVE INTERFERENCE See destructive superposition. (Unit 10)

DESTRUCTIVE PLATE MARGIN A boundary between two lithospheric plates at which oceanic lithosphere is destroyed by subduction into the mantle. Destructive margins involve the collision of oceanic lithosphere with either oceanic lithosphere to produce an island arc, or with continental lithosphere to produce an Andean-type mountain chain. (Units 7–8)

DESTRUCTIVE SUPERPOSITION (destructive interference) When two waves of equal amplitude and equal wavelength are exactly out of phase, they generate destructive superposition in which the resultant amplitude is zero. (Unit 10)

DETRITAL GRAINS Minerals (or more rarely rock fragments) that have been eroded from pre-existing rock and deposited unaltered into new sediments. (Units 28–29)

DETRITIVORE Animals that consume dead plant and animal detritus. (Unit 25)

DETRITUS Dead organic matter, e.g. excreta and dead organisms or parts of organisms. Parts of plants that are shed are also called litter. (Unit 25)

DIABETES A disease resulting from a defect in the system for the regulation of the concentration of glucose in blood. Insulin is not produced in sufficient amounts, or is not produced at all. (Unit 23)

DIAPYRS Large bodies of magma that rise into the upper crust because they are less dense than surrounding rocks. (Unit 27)

DIFFERENTIATION (biology) The formation of cells different from each other and from the original fertilized egg. (Unit 24)

DIFFRACTION The process in which waves can 'bend around' corners or obstacles. The 'degree of bending' depends on the relationship between the size of the obstacle and the wavelength of the wave; diffraction effects are negligible when the wavelength is much less than the dimensions of the object, and is most noticeable when the wavelength is of about the same size as the object. (Unit 10)

DIFFRACTION EQUATION The equation that specifies the angular directions θ_n of constructive superposition produced by either a double-slit or a diffraction grating. The equation is $d \sin \theta_n = n\lambda$, where d is the separation of the slits, λ is the wavelength, and n is a whole number. (Unit 10)

DIFFRACTION GRATING An object composed of a very large number of equally-spaced, parallel slits. (Unit 10)

DIFFRACTION ORDER The term used to describe the value of n in the diffraction equation $d \sin \theta_n = n\lambda$, as applied to a diffraction grating. When $n = 1$, the diffraction pattern is said to be first order; when $n = 2$ it is said to be second order, and so on. The whole number n is a measure of the number of wavelengths difference in the paths traversed by light from adjacent slits in the grating. In the straight-ahead direction $n = 0$ and the pattern is said to be in zeroth order. (Unit 10)

DIFFUSION The process by which a solute moves from a region of higher concentration to one of lower concentration. The solute may be a gas, ions, a dye, etc. (Unit 23)

DILATATION See rarefaction pulse.

DIMENSIONS Quantities with units that differ only by a (numerical) conversion factor are said to have the same dimensions. The three basic dimensions are length, time and mass. (Unit 2)

DINOSAUR An extinct reptile belonging to a group that constituted the dominant land animals of the Jurassic and Cretaceous Periods. Many of the herbivorous dinosaurs were amphibious or semiaquatic. (Units 28–29)

DIPLOID NUMBER The number of chromosomes found in non-reproductive body cells (somatic cells) is called the diploid number. A cell that has the diploid number of chromosomes is said to be diploid. (Unit 20)

DIPOLE DIPOLE FORCES The net attraction between the dipoles in two (or more) molecules, as a result of the attractions between the unlike charges slightly outweighing the repulsions due to the like charges. (Units 17–18)

DIPOLE WOBBLE The slight variation with time in the position of the Earth's geomagnetic poles relative to the axis of rotation. The difference in direction appears to have been at most about 11° during the past 7000 years. (Units 5–6)

DISACCHARIDE A molecule formed by the condensation of two monosaccharides. There are many types, e.g. sucrose and lactose.

DISCONTINUOUS VARIATION Variations in a phenotypic character that are distinct or abrupt rather than smooth and continuous. (Unit 20)

DISULPHIDE BRIDGE An $-S-S-$ covalent link formed between two cysteine residues, usually widely separated in a protein's primary structure. They can occur within a single polypeptide chain and they can occur between different polypeptide chains in a protein (e.g. between the A and B chains in insulin). Disulphide bridges stabilize the higher-order structure of a protein molecule. (Unit 22)

DIVISIONS I AND II OF MEIOSIS The two successive divisions that collectively make up the process of meiosis. Division I results in the separation of the chromosomes of a homologous pair. Division II results in the separation of the chromatids of each chromosome. (Unit 20)

DNA (DEOXYRIBONUCLEIC ACID) A heteropolymer in which the monomer is a composite molecule consisting of a phosphate group joined to a deoxyribose molecule, which in turn is joined to one of four different organic bases—adenine, guanine, cytosine or thymine. Molecules of DNA can be very large: some molecules of human DNA have relative molecular masses as high as 10^{12} . (Units 17–18)

The monomers of DNA are called deoxyribonucleotides and thus the heteropolymer is a polydeoxyribonucleotide. Each DNA molecule consists of two such polymeric strands wound round each other to form a double helix. In eukaryotic cells, the DNA of the nucleus is found, in conjunction with histones, in chromosomes. Such DNA carries the genetic information of the cell, coded as a sequence of deoxyribonucleotides (and hence a sequence of bases). (Unit 24)

DNA REPAIR MECHANISMS Mechanisms by which cells repair alterations in DNA caused by mutation. These repairs are directed by specific enzymes in the cell nucleus. (Unit 24)

DOMINANT CHARACTER If an animal or plant is heterozygous at a particular locus, and if the phenotypic character of only one of the alleles at that locus is shown, then that character is said to be dominant. (The one that does not appear is said to be recessive.) The allele responsible for the dominant character is also termed the dominant allele. (Unit 20)

DOUBLE BOND A bond between two atoms of a chemical substance, which is equivalent to two single bonds; in electronic theories of bonding, it is represented by two shared pairs of electrons. (Units 13–14 and Units 17–18)

DOUBLE CIRCULATION The arrangement of the circulatory system in mammals and birds. Blood passes round the pulmonary circulation and back to the heart before entering the systemic circulation. (Unit 23)

DOUBLE HELIX The configuration of the two strands of polydeoxyribonucleotide wound around each other to give a molecule of DNA. (Unit 24)

DOUBLE-SLIT An arrangement of two adjacent narrow parallel slits in an opaque background, separated by a short distance. (Unit 10)

DRIFT CHAMBER A type of charged-particle detector used in high-energy physics. (Unit 32)

DYKE A sheet-like igneous body that is intruded into existing rocks, and that cuts across their bedding. In horizontal strata, dykes are often vertical (contrast sill). (Units 7–8)

E

EARTH SCIENCES An integrated science concerned with the interior and surface of the Earth, and its evolution. (Units 5–6)

ECHINOID Scavengers and predators, related to modern sea urchins and starfish, that show five-fold symmetry. Common in the fossil record since the Mesozoic Era. (Units 28–29)

ECLIPSE The total or partial obscuring of one celestial body by another. (Unit 1)

ECLIPTIC PLANE The plane of the Earth's orbit around the Sun. (Units 28–29)

ECOLOGY The study of the interaction of organisms with each other and with their environment. (Unit 25)

ECOSYSTEM A unit usually comprising several habitats and their many communities of organisms, together with their physico-chemical environment. (Unit 25)

EDIACARAN FAUNA Fossils from the locality of Ediacara (South Australia) and elsewhere, which comprise some of the oldest known Metazoan fauna. (Units 28–29)

EFFECTOR A part of a control system that produces an appropriate response to a signal from a receptor. (Unit 23)

EFFUSIVE (Earth sciences) Description of volcanic rocks that result from 'quiet' extrusive activity, with only a slight escape of dissolved gases from the magma during eruption of a volcano. (Units 5–6)

EGG A female gamete. The term can be applied to plants or animals. (Unit 20)

EINSTEIN'S EQUATION The equation, $E = mc^2$, that gives the energy E that is equivalent to mass m (c is the speed of light in a vacuum). The equation is one of the predictions of the special theory of relativity. (Unit 31)

EINSTEIN'S PHOTOELECTRIC EQUATION According to Einstein's theory of the photoelectric effect, the maximum kinetic energy $(E_k)_{\max}$ of a photoelectron ejected from a solid is equal to the energy of the incident photon (hf , where h is Planck's constant and f is the frequency of the radiation) minus the work function ϕ of the solid: $(E_k)_{\max} = hf - \phi$. (Unit 10)

ELASTICITY The property of returning to the original shape after being distorted by the application of a force. Elasticity is a characteristic property of most solid materials, e.g. a rock. (Units 5–6)

ELASTIC MODULUS The ratio of the magnitude of the applied stress to the magnitude of the resulting strain produced when a material is compressed or deformed. (Units 5–6)

ELECTRICAL CONDUCTOR A material through which an electric current can flow. (Units 5–6)

ELECTRICAL ENERGY Fundamentally, this is the form of energy that a charged particle has by virtue of its position. When a positive charge Q moves through a voltage difference ΔV , the electrical energy transferred is $Q \Delta V$. Electrical energy is converted in, for example, electrical appliances. (Unit 9)

ELECTRIC CURRENT The flow of electrically charged particles, called electrons, through an electrical conductor. More specifically, electric current is the rate of flow of electric charge past a point. In metallic conductors, current is carried by electrons. The SI unit of electric current is the (ampere) amp, A. (Units 5–6 and 9)

ELECTRIC DIPOLE Equal and opposite electric charges separated by a short distance. In molecules containing a variety of atoms, the electrons forming the covalent bonds between atoms of different elements are not shared equally between the two atoms involved (see electronegativity). The result is a dipole, in which one atom has a slight positive charge and the other a slight negative charge. Such a dipole is also called a polar bond. (Units 17–18)

ELECTRODE One of the two parts of the external circuit that make contact with the solution during electrolysis. (Units 13–14)

ELECTROLYSIS The process of chemical decomposition of a liquid that occurs when the liquid conducts electricity. (Units 13–14)

ELECTROLYTE A substance that dissolves in a liquid and increases the ability of the liquid to conduct electricity. (Units 13–14)

ELECTROMAGNETIC RADIATION This is the collective name given to γ -radiation, X-rays, ultraviolet radiation, visible light, infrared radiation, microwaves and radio waves—the parts of the electromagnetic spectrum. (Unit 10)

ELECTROMAGNETIC SPECTRUM The complete spectrum (i.e. complete range) of electromagnetic waves. It extends from the comparatively long-wavelength radio waves, through microwaves, infrared radiation, visible light, ultraviolet radiation and X-rays, to the comparatively short-wavelength γ -rays. (Unit 10)

ELECTROMAGNETIC WAVES These are waves in which the periodic variables are electric and magnetic fields. These waves travel in a vacuum at the speed c , which is approximately $3 \times 10^8 \text{ ms}^{-1}$. (Unit 10)

ELECTRON A fundamental particle that is a constituent of every atom. The charge of an electron is $-e \approx -1.602 \times 10^{-19} \text{ C}$, and its mass is approximately $1/1836$ times the mass of a proton. The electron is a member of the lepton family. (Unit 32)

ELECTRONEGATIVITY The power of an atom to attract electrons to itself during chemical combination. (Units 13–14)

ELECTRON ENERGY LEVEL An allowed energy that an electron may have. (Units 11–12)

ELECTRON ENERGY-LEVEL DIAGRAM A diagram showing the allowed energy levels of an electron in a quantized system, such as an atom. (Units 11–12)

ELECTRONIC CONFIGURATION A shorthand description of the electrons within shells and subshells in an atom, according to the quantum numbers that describe the electrons. For example, sodium is represented as $1s^2 2s^2 2p^6 3s^1$. (Units 11–12)

ELECTRONIC CONFIGURATION OF A NOBLE GAS The electronic configuration of the free atom of one of the six noble gases. An example is the configuration $1s^2 2s^2 2p^6$, which is that of a free neon atom. (Units 13–14)

ELECTRONIC STRUCTURE The arrangement of electrons in energy levels within an atom. (Units 11–12)

ELECTRON SHELL A grouping of electrons within an atom, in which the electrons have the same principal quantum number n and possess similar energies. (Units 11–12)

ELECTRON SPIN The intrinsic spin of an electron, which accounts for its magnetic properties and those of certain atoms that contain unpaired electrons. See magnetic spin quantum number. (Units 11–12)

ELECTRON SUBSHELL A grouping of electrons within an atom in which the electrons have the same energies within the subshell but different energies from those in other subshells. Electrons in a subshell have the same quantum number l . (Units 11–12)

ELECTRON TRANSPORT CHAIN The array of hydrogen (and electron) carriers in the inner mitochondrial membrane that, through sequential oxidation and

reduction, bring about the reactions $\text{NADH}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{NAD} + \text{H}_2\text{O}$ and $\text{FADH}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{FAD} + \text{H}_2\text{O}$, linked with the production of ATP by oxidative phosphorylation. (Unit 22)

ELECTRONVOLT, eV The amount of energy required to accelerate an electron through a potential difference of one volt: $1 \text{ eV} \approx 1.602 \times 10^{-19} \text{ J}$. (Unit 9)

ELECTROSTATIC FORCE The principal type of force between stationary, charged objects. (Unit 9)

ELEMENT See chemical element.

ELLIPSE An oval shape that is defined mathematically as the curve for which the sum of the distances from the two foci (fixed points within the ellipse) is a constant for all points on the curve. (Unit 2)

EMISSION SPECTRUM A spectrum produced when emitted electromagnetic radiation is displayed as a spread of frequencies. Atomic emission spectra consist of discrete frequencies and appear as lines. (Units 11–12)

EMPIRICAL FORMULA A formula that represents with chemical symbols the simplest ratio of the numbers of atoms in a chemical compound. For example, carbon and hydrogen form a molecular compound called ethene, in which the atomic ratio C:H is 1:2. The empirical formula is therefore CH_2 , although the molecular formula is actually C_2H_4 . (Units 13–14)

ENDOPLASMIC RETICULUM The labyrinth of membranes within cells that is bathed by the cytosol. Ribosomes are frequently found attached to membranes of the endoplasmic reticulum. It is then called rough endoplasmic reticulum. The so-called smooth endoplasmic reticulum is not associated with ribosomes. (Unit 22)

ENDOTHERMIC REACTION A chemical reaction during which heat is transferred to the reacting chemicals from their surroundings. (Unit 16)

ENERGY CONVERSION The transformation of energy from one form into one or more other forms. (Unit 9)

ENERGY LEVELS Discrete values of the energy of a particle. Electrons in an atom have energy levels, as do protons and neutrons in nuclei. (Unit 31)

ENERGY OF THE ENVIRONMENT (Earth sciences) The energy of the transporting medium. This is the most important factor governing the transport and sorting of particles, and whether a particle of a given size will be transported or not. (Unit 27)

ENERGY TRANSDUCER A chemical agent that links together processes that make energy available (e.g. oxidative catabolism) and processes that require energy (e.g. muscle contraction). ATP is the commonest energy transducer in cells and works through the interconversion of ATP and $\text{ADP} + \text{P}_i$. (Unit 22)

ENTHALPY OF REACTION, ΔH A quantity equal to the heat transferred from the surroundings to the reacting chemicals when a chemical reaction occurs at a fixed temperature and pressure. It is positive for an endothermic reaction and negative for an exothermic reaction. (Unit 16)

ENVIRONMENT See habitat

ENZYME A biological catalyst. (Units 17–18)

More precisely, a biological catalyst composed entirely or partially of protein. A given enzyme is able to catalyse a particular reaction or type of reaction. The names of enzymes end in -ase, the preceding part of the name usually being the name of the substrate or the class of substrate or the type of reaction catalysed or some mixture of these, e.g. lactate dehydrogenase catalyses the dehydrogenation of lactic acid to pyruvic acid (and also the reverse reaction). Enzymes are coded for by structural genes. (Unit 22)

ENZYME ACTIVITY The activity of an enzyme is the initial rate of the reaction catalysed by that enzyme, under specified conditions of temperature and pH. Provided the substrate is in excess, activity is directly proportional to enzyme concentration. The relative concentrations of solutions of a particular enzyme are measured by comparing the activities of the solutions. (Unit 22)

ENZYME ASSAY Measurement of the amount of a particular enzyme in solution. An enzyme is assayed by measuring either the rate of disappearance of the substrate or the rate of formation of the product, under specified conditions. (Unit 22)

ENZYME CATALYSIS Catalysis is the marked increase in reaction rate occurring when an added substance (the catalyst) lowers activation energy. Enzyme catalysis is catalysis brought about by enzymes. (Unit 22)

ENZYME SPECIFICITY A characteristic property of enzymes whereby a given enzyme is able to catalyse only one reaction or type of reaction. Some enzymes show absolute specificity (catalyse only one reaction), e.g. lactate dehydrogenase, which interconverts lactate and pyruvate. Others show relative specificity (catalyse a particular kind of reaction with various possible substrates), e.g. lipase, which hydrolyses a variety of fats to fatty acids and glycerol. (Unit 22)

ENZYME-SUBSTRATE COMPLEX The complex that is reversibly formed when an enzyme binds to its substrate or substrates. Once it is formed, catalysis occurs, the product is released and the enzyme is thereby regenerated. (Unit 22)

EPICENTRAL ANGLE The angle subtended at the centre of the Earth by the arc linking the epicentre of an earthquake with a recording station. The angle is measured between two imaginary Earth radii intersecting the epicentre and the recording station. (Units 5–6)

EPICENTRE OF AN EARTHQUAKE The point on the Earth's surface vertically above the focus of an earthquake. (Units 5–6)

EQUILIBRIUM CONSTANT A mathematical quantity derived from a balanced chemical equation. The concentrations of the reactants and products are raised to the powers of the numbers that precede them in the equation. The concentrations of the products, thus adjusted, are then multiplied together, and divided by the similarly adjusted concentrations of the reactants multiplied together. When the system defined by the balanced equation is in chemical equilibrium, this quantity is constant at constant temperature. (Unit 15)

ERA The largest unit of geological time based on fossil characteristics in sedimentary rocks. Earth history is divided into four Eras: Precambrian, Palaeozoic, Mesozoic and Cainozoic (also spelt Cenozoic). (Units 28–29)

EROSION The process of wearing away the surface of the Earth's crust usually by the mechanical action of water or ice or by particles transported by wind, water or ice. (Units 5–6 and 27)

ERROR BAR A line on a graph, representing the range of uncertainty in a datum 'point'. (Unit 3)

Vertical error bars normally represent confidence limits in measured values of the dependent variable; horizontal error bars normally represent uncertainties in set values of the independent variable. (Unit 4)

ESTER A compound with molecules that contain an ester group, —C—O—C— . In biology, an important class



of esters is the fats. (Units 17–18)

ETHER A compound with molecules that contain an ether group, C—O—C— . (Units 17–18)

EUKARYOTE An organism whose cells contain nuclei within which lie the chromosomes. Eukaryotic cells also contain other organelles in addition to nuclei. (Units 19 and 28–29)

EUSTATIC CHANGES Changes in sea-level due to changes in the total volume of water available. They are mainly controlled by the size of the polar ice-caps. (Units 28–29)

EUTROPHICATION The enrichment of aquatic environments with high levels of dissolved plant nutrients, such as nitrate and phosphate ions, leading to very high algal production. Consequent growth is often excessive (judged from a human standpoint). Eutrophication is a natural process, but it may also be caused by human activity. (Unit 25)

EVAPORITE In isolated inland seas, or newly formed ocean basins where circulation is restricted, evaporation of water that exceeds the input from rivers etc. can take place. The remaining water becomes saturated with ions such as Na^+ , K^+ , Cl^- , SO_4^{2-} . Salts such as common

table salt (NaCl) and gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) may be precipitated and accumulate as sedimentary rocks, which are called evaporites. (Unit 27)

EVOLUTION The historical changes that have occurred in the phenotypes of organisms. See Darwin's theory of evolution by natural selection. (Unit 19)

EVOLUTIONARY TREE A diagrammatic device that represents time vertically up the page and the evolutionary history of organisms as branches of a tree. (Unit 21)

EXCITED NUCLEUS An atomic nucleus that has an energy greater than its minimum possible energy. (Unit 31)

EXCITED STATE OF AN ATOM A state of an atom in which one or more electrons occupy energy levels above the lowest possible values. (Units 11–12)

EXONS The coding sequences of a split gene. Together with non-coding intron sequences, exons are transcribed into a non-functional mRNA molecule. After removal of the transcribed intron sequences, the transcribed exon sequences are 'spliced' together to make a functional mRNA molecule that can be translated to make a functional protein. (Unit 24)

EXOTHERMIC REACTION A chemical reaction during which heat is transferred from the reacting chemicals to their surroundings. (Unit 16)

EXPERIMENTAL DATA The observations, particularly numerical measurements, from an experiment. (Unit 1)

EXPLOSIVE (Earth sciences) Description of volcanic rocks that result from violent extrusive activity, caused by sudden escape of a large quantity of dissolved gases from the magma during eruption of a volcano.

EXPONENTIAL DECAY A type of decay in which a quantity always decreases by a fixed factor in each successive (fixed) time interval. (Units 11–12)

EXPONENTIAL GROWTH A type of growth in which a quantity always increases by a fixed factor in each successive (fixed) time interval. For example, a bacterial population that doubles every half hour exhibits exponential growth: in this case, the fixed factor is 2. (Unit 19)

EXTENDED COVALENT SUBSTANCE A solid substance with a structure in which entire crystals are held together by a three-dimensional array of covalent bonds, and in which an inspection of the structure provides no justification for singling out discrete molecules with the same empirical formula as the substance. (Units 13–14)

EXTRACELLULAR FLUID The fluid outside cells through which substances are continually exchanged between cells and tissues. Blood plasma is part of the extracellular fluid. (Unit 23)

EXTRAPOLATION The extension of the line on a graph beyond the range of values within which measurements have been made. (Unit 2)

EXTRUSIVE (Earth sciences) Description of igneous rocks that have erupted as magma at the Earth's surface. Characterized by fine-grained crystalline rocks, such as basalts, andesite and rhyolite. (Units 5–6)

F

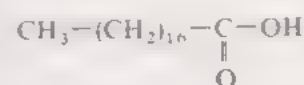
FAD (flavin adenine dinucleotide) An important hydrogen-carrying coenzyme involved in (for example) the tricarboxylic acid cycle and the β -oxidation pathway. Its reduced form is FADH_2 ; this is reoxidized to FAD via the electron transport chain yielding two ATPs per molecule of FADH_2 oxidized. (Unit 22)

FALSIFIABILITY CRITERION According to one common theory of the scientific method, a general statement can be scientific if and only if one can conceive of an observation or experimental result that can logically prove it wrong. (Unit 1)

FAMILY (biology) Part of the taxonomic hierarchy. Several genera form one family and several families form one order. (Unit 21)

FAT An ester of fatty acids and glycerol. A molecule of fat is formed by the condensation of one molecule of glycerol with three molecules of long-chain fatty acid (e.g. palmitic or stearic acid). Fats are also called triglycerides. (Unit 22)

FATTY ACID A long-chain carboxylic acid produced from fats by hydrolysis. Examples are: palmitic acid, $\text{CH}_3-(\text{CH}_2)_{14}-\text{C}-\text{OH}$; and stearic acid,



(Unit 22)

FAULT A fracture in the Earth's crust along which movement takes place. (Units 5–6)

A planar crack running through rocks across which relative movement has occurred. Faults can be of any scale, from a displacement of a few centimetres (which may be visible in the rocks of, for example, a road cutting) to fractures of continental proportions (visible on satellite images). The main types of fault are caused by compression, tension or wrenching. (Unit 27)

FECUNDITY The number of fertilized eggs to whose production an organism contributes. (Unit 19)

FELDSPAR An important group of rock-forming silicate minerals. The composition can vary between $\text{CaAl}_2\text{Si}_2\text{O}_8$ and $\text{NaAlSi}_3\text{O}_8$ (plagioclase feldspars) or KAlSi_3O_8 (potassium feldspar). The colour can vary

from white to pink, and specimens usually show at least one good cleavage. Hardness is about the same as steel. (Unit 27)

FERMENTATION The anaerobic catabolism of glucose to ethanol. (Unit 22)

FERROMAGNETIC MINERALS Minerals that are rich in iron and magnesium. (Unit 27)

FIBROUS PROTEIN A fibrous protein molecule is a large polypeptide (i.e. made up of many amino acid residues linked together by amide (peptide) bonds) in which there are often repetitive sequences of particular amino acids; a given fibrous protein consists of molecules of various lengths, in contrast to globular proteins. They occur in living systems as structural materials (for example, wool and hair) in which they are arranged parallel to one another as long threads, very similarly to the structure of synthetic polyamides such as nylon-6. Fibrous proteins are insoluble in water (See also globular protein.) (Units 17–18)

FIELD OF FORCE This describes the action on one object situated in the space around a second object when the second object exerts a force (e.g. a gravitational or magnetic force) on the first object. At each point in the field, the magnitude and direction of the force can be measured using a suitable test object and measuring instrument. (Units 5–6)

FIRST CARNIVORE A flesh-eating animal that eats herbivores. (Unit 25)

FIRST FILIAL GENERATION, F_1 The first generation of offspring produced when parental strains (usually pure-breeding) are crossed. (Unit 20)

FIRST IONIZATION ENERGY, I_1 The energy required to remove the least tightly bound electron from an atom in its ground state. (Units 11–12)

FITNESS The ability of an organism to survive and leave offspring that themselves can survive and leave offspring. Two individuals of the same species may have different fitnesses. (Unit 19)

FIXATION The situation in which an allele has spread through a gene pool, so that the only other alleles present at the same locus in the gene pool arise through mutation. (Unit 21)

FIXED-TARGET EXPERIMENT An experiment in which a beam of particles, e.g. protons, is made to collide with a stationary target. (Unit 32)

FOCUS OF AN EARTHQUAKE The point of first movement on a fault at the beginning of an earthquake. (Units 5–6)

FOLDING/FOLDS (Earth sciences) Bending or crumpling observed in crustal rocks subjected to compressive forces. The rocks have absorbed the stress by folding, rather than fracturing and faulting. Folds are

particularly well displayed in layered sedimentary rocks and may form arched or basin-shaped structures. (Units 5–6 and 27)

FOOD CHAIN A sequence of organisms, usually beginning with plants, that successively depend on each other for food. The food chain shows the direction of energy flow between organisms. (Unit 25)

FOOD WEB A group of inter-linked food chains that shows how energy flows through an ecosystem. (Unit 25)

FORCE External agency that is capable of imparting an acceleration to an object. The magnitude of the force F that will give an acceleration of magnitude a to a body of mass m is given by $F = ma$ (Newton's second law). If only one force is acting, the direction of the acceleration will be the same as that of the force. The SI unit of (magnitude of) force is the newton, N; $1 \text{ N} = 1 \text{ kg m s}^{-2}$. (Unit 3)

FORESHOCKS Earthquakes that occur minutes to days before a severe earthquake. Their magnitudes are lower than those of the main earthquake. (Units 5–6)

FORMULA See chemical formula

FOSSILS Remains or traces of animals and plants that have been preserved in rocks. (Units 5–6 and 28–29)

FOUCAULT PENDULUM EXPERIMENT An experiment that involves the apparent rotation of the plane-of-swing of a pendulum on Earth. The experiment demonstrates that the Earth is spinning. (Unit 1)

FRACTIONAL CRYSTALLIZATION The process by which crystals of a mineral are removed from a magma to produce a magma with a different composition from the original melt. (Unit 27)

FRAGMENTAL TEXTURE The texture of rocks that are composed of individual grains cemented together. Most sedimentary rocks have a fragmental texture. (Units 5–6)

FRAUNHOFER DIFFRACTION The special case of diffraction in which the pattern is observed at an infinite distance away from the diffracting object. Since a convex lens brings parallel light to a focus, the Fraunhofer diffraction pattern will also be observed at the focus of such a lens. (Unit 10)

FRAUNHOFER LINES The absorption lines observed in the Sun's spectrum, produced by absorption of radiation by atoms and ions in the Sun's atmosphere. (Units 11–12)

FREE PARTICLE A particle that is not subject to a net force. (Unit 30)

FREQUENCY OF A WAVE The rate at which complete wave-cycles pass a fixed point. The frequency is given by $f = 1/T$ (where T is the period) and it is mea-

sured in hertz (Hz), where $1\text{ Hz} = 1\text{ cycle per second} = 1\text{ s}^{-1}$. The frequency of a wave with constant speed v is related to its wavelength λ by the equation $v = f\lambda$. (Unit 10)

FROTHY BASALT See vesicular basalt.

FUNCTIONAL GROUP In many reactions of carbon compounds, it is observed that only certain groups of atoms are directly involved. It is the nature of these groups of atoms that primarily determines the type of reaction that takes place; the constitution of the hydrocarbon skeleton only has a secondary influence, affecting, for example, the rate of the reaction but not altering the nature of the reaction. Such groups of atoms are called functional groups, and common examples are the hydroxyl group, $-\text{OH}$, the amino group, $-\text{NH}_2$, and the carboxyl group, $-\text{C}-\text{OH}$.



(Units 17–18)

FUNCTIONAL ISOMERS Two molecules are functional isomers if they are structural isomers with different functional groups. An example of such a pair is ethanol, $\text{CH}_3-\text{CH}_2-\text{OH}$ (an alcohol), and methoxymethane, $\text{CH}_3-\text{O}-\text{CH}_3$ (an ether). (Units 17–18)

FUNCTIONAL PROTEIN A biologically active protein molecule. (Unit 24)

FUNDAMENTAL INTERACTION A type of interaction that cannot be understood theoretically in terms of a more basic type of interaction. There are currently believed to be four fundamental interactions: strong, gravitational, weak and electromagnetic (although the Weinberg-Salam theory gives a unified description of the latter two types of interaction). (Unit 32)

FUNDAMENTAL NICHE See niche. (Unit 25)

FUNDAMENTAL PARTICLE A particle that has no constituents. It is currently believed that there are three types of fundamental particle: leptons, quarks and gauge bosons. (Unit 32)

G

GABBRO A coarse-grained intrusive igneous rock with a chemical composition identical with that of basalt, formed as a result of the slow cooling of magma of basaltic/gabbroic composition. It often occurs beneath the basalts of the ocean floor, as well as in lesser amounts within the continental crust. (Units 5–6)

Gabbro consists mostly of plagioclase and pyroxene crystals. (Unit 27)

GAMETES The reproductive cells produced by organisms that reproduce sexually. They are haploid. Male gametes are called sperms or spermatozoa in animals and sperm cells (formed within pollen grains) in

plants. Female gametes are called eggs or ova in animals and egg nuclei (formed within ovules) in plants. (Units 19 and 20)

γ -DECAY The process in which a γ -ray photon is ejected from a nucleus. The process, which is one of the types of radioactive decay, occurs when an excited nucleus makes a transition to a lower energy level, e.g. $^{115}_{49}\text{In}(\text{excited}) \rightarrow ^{115}_{49}\text{In} + \gamma$. (Units 11–12 and 31)

γ -RADIATION Electromagnetic radiation of wavelength shorter than X-rays; γ -radiation is emitted in γ -decay.

GAUGE BOSONS A class of particles, currently believed to be fundamental, that mediate interactions between fundamental particles. Each type of fundamental interaction is mediated by a characteristic type of gauge boson: strong interactions (between quarks) by gluons, electromagnetic interactions by the photon, weak interactions by intermediate vector bosons, and gravitational interactions by the graviton. (Unit 32)

GAY-LUSSAC'S LAW When gases react at constant temperature and pressure, they do so in volumes that are in a simple ratio to one another, and to the volume of a product if it is gaseous. (Units 13–14)

GENE The unit of inheritance. (Unit 19)

Although there are several types of gene, each consists of a length of DNA containing a particular instruction. (Unit 20)

Those that affect phenotype through the synthesis of proteins are called structural genes: in eukaryotes, structural genes are frequently split genes. In addition, in all organisms there are control genes, and genes that code for tRNA and rRNA. (Unit 24)

GENE POOL The set of genes that a population inherits from its parent population. (Unit 21)

GENETIC CODE The sequence of bases in the RNA (and DNA) that codes for the correct position of amino acids relative to each other. It is a degenerate code containing 64 codons. (Unit 24)

GENETIC DRIFT A random fluctuation in allele frequency over time, due to chance occurrences alone. (Unit 21)

GENETIC ENGINEERING A change in the genetic material within living cells, brought about by artificial means. For example, if a synthetic DNA molecule is introduced into a bacterium, the latter may both replicate this molecule and translate it, so making the protein coded by the synthetic DNA. (Unit 24)

GENETIC FINGERPRINTING A technique that exploits the variability of the non-coding regions of DNA between individuals, and enables the genetic relationship between individuals to be determined. The technique also allows genetic material (e.g. blood from the scene of a crime) to be matched to specific individuals. (Unit 24)

GENOME The complete collection of genes in a cell. (Unit 20)

GENOTYPE The genetic characteristics of an organism. (Unit 20)

GENUS (plural genera) Part of the taxonomic hierarchy. A genus contains several or many related species. Several genera form one family. (Unit 21)

GEOCENTRIC MODEL OF THE UNIVERSE A model of the Universe according to which the Sun, the Moon, the stars and the planets all travel round the Earth. (Unit 1)

GEOGRAPHICAL ISOLATION Physical isolation of one part of a population from another as a consequence of geographical constraints. It may result in reproductive isolation. (Unit 21)

GEOMAGNETIC POLES The points where the Earth's magnetic dipole axis cuts the surface of the Earth; at present they lie 11° of latitude away from the geographic poles. (Units 5–6)

GEOMETRIC ISOMERS Two molecules are geometric isomers if they are stereoisomers with groups arranged differently in space at the ends of a double bond. (Units 17–18)

GERM CELLS Another name for gametes. (Unit 19)

GLACIAL PERIOD See ice age.

GLASSY TEXTURE When magma is cooled extremely quickly, crystallization is instantaneous and individual crystals have no opportunity to grow. Therefore instead of having a crystalline texture, the magma becomes a solid glass. (Units 5–6)

GLOBIN The protein part of a haemoglobin or myoglobin molecule (the rest, in the case of haemoglobin, consists of four haem groups; in the case of myoglobin, of one haem group). (Unit 23)

GLOBULAR PROTEIN A molecule consisting of one or more polypeptide chains that has a specified biological role. A given globular protein consists of molecules of identical structure and size, in contrast to fibrous proteins. Globular proteins are generally coiled into broadly spherical shapes and are soluble in water. The precise globular structure arises directly from the primary structure of the polypeptide(s) as a consequence of the formation of weak bonds between specific amino acid residues. Most of the known enzymes (biological catalysts) are globular proteins. (See also fibrous protein.) (Units 17–18)

GLUCAGON A hormone that promotes glycogenolysis in the liver, and increases the rate of gluconeogenesis. (Unit 23)

GLUCONEOGENESIS The synthesis of glucose from a variety of substrates. (Unit 23)

GLUCOSE A monosaccharide with the molecular formula $C_6H_{12}O_6$. Glucose is a major metabolic fuel and is also the constituent monomer in several important polysaccharides, e.g. amylose, amylopectin, glycogen and cellulose. (Unit 22)

GLUCOSE RESIDUE The repeating unit in polysaccharides of glucose. Glucose residues in polysaccharides are analogous to amino acid residues in proteins, i.e. the monomer molecule minus the atoms of water (H_2O). (Unit 22)

GLUON The type of gauge boson that mediates the strong interactions between quarks (and between antiquarks). According to quantum chromodynamics, there should exist eight different types of gluon, each with zero rest mass and zero electric charge. No isolated gluon has ever been observed and, according to quantum chromodynamics, such an observation will never be made. (Unit 32)

GLYCEROL A C_3 molecule containing three hydroxyl groups, one on each carbon atom. This alcohol condenses with fatty acids to give esters called fats. (Unit 22)

GLYCOGEN A food-storage polysaccharide in animal tissue, especially liver and muscle. It is a polymer of glucose with residues linked by α -1,4 glycosidic bonds and with α -1,6 bonds at the branch points, a structure similar to that of amylopectin (a food storage polysaccharide in plant cells). Like glucose, glycogen is catabolized via the glycolytic pathway. (Unit 22)

GLYCOGENOLYSIS The breakdown of glycogen to glucose. It occurs principally in the liver. (Unit 23)

GLYCOLYSIS (also called the glycolytic pathway) A sequence of catabolic reactions occurring in the cytosol by which each molecule of glucose is converted into two pyruvic acid molecules, with the production of two $NADH_2$ and two ATP molecules (by substrate level phosphorylation). Under aerobic conditions the pyruvic acid and $NADH_2$ are catabolized further to carbon dioxide and water. The catabolism of glycerol and some amino acids feeds into the glycolytic pathway. (Unit 22)

GLYCOSIDIC BONDS The links between the constituent monosaccharide residues in polysaccharides and disaccharides. Glycosidic bonds are analogous to peptide bonds in proteins, being the link formed as the monomers condense. There are three main types of glycosidic bond in common polymers of glucose: α -1,4 bonds, α -1,6 bonds and β -1,4 bonds. The α and the β refer to the configuration of the bond at carbon atom C-1. The numbers refer to the glucose carbon atoms involved in the bond. (Unit 22)

GNEISS A coarse-grained metamorphic rock, composed of alternating light and dark bands. The pale minerals are quartz and feldspar, the dark minerals are iron-rich and can include mica. Gneiss is formed at very high temperatures and pressures, just before the melting

temperatures of rocks of this composition are reached, and can be derived from either igneous or sedimentary parents. (Unit 27)

GRADED BEDDING A texture of a sedimentary or volcanic rock that shows a progressive change in grain size from the base to the top of the bed. (Units 28–29)

GRADIENT OF STRAIGHT-LINE GRAPH The 'slope' of the line (i.e. the vertical rise divided by the corresponding horizontal run). (Unit 3)

GRANITE A coarse-grained, intrusive igneous rock, composed largely of interlocking crystals of quartz and feldspar (often with mica). It is formed from a silica-rich magma, which rises in the crust and slowly crystallizes over many thousands (sometimes millions) of years. (Units 5–6)

Granites may be formed by extreme fractional crystallization of basaltic or andesitic magmas, or by partial melting of crustal rocks. They are typically found at destructive plate margins. (Unit 27)

GRAPH A plot of (normally two) quantities against each other along mutually perpendicular axes. (Unit 2)

GRAVITATIONAL CONSTANT, G A universal constant in Newton's theory of gravitation. $G \approx 6.672 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$. (Unit 3)

GRAVITATIONAL ENERGY The energy an object possesses by virtue of its position in a region in which it is subjected to a gravitational attraction. An object of mass m , situated at a vertical height Δh above some fixed point, has gravitational energy $mg\Delta h$ with respect to that point, where g is the magnitude of the acceleration due to gravity in that region. (Unit 9)

GRAVITON G The type of gauge boson that is currently believed to mediate gravitational interactions. The graviton has not yet been detected, but it is expected that the particle will be found to have zero rest mass and zero electric charge. (Unit 32)

GRAVITY According to Newton's law of gravitation, gravity is the phenomenon of attraction between any mass and all the other masses in the Universe. In colloquial speech, the term is usually taken to describe the attraction of objects on or near the Earth's surface towards the centre of the Earth. (Unit 3)

GRAVITY ANOMALY The amount by which the measured acceleration due to gravity at any place differs from the theoretical value calculated on the assumption that the Earth is radially symmetrical and a spheroid that is slightly flattened at the poles. Gravity anomalies are usually measured in the (non SI) unit of the milligal, which has the dimensions of acceleration. (Units 7–8)

GREENHOUSE EFFECT A rise in average global temperature caused by increases in the amount of carbon dioxide and other gases in the atmosphere as a result of human activities. (Unit 25)

This effect is caused by the transmission of short-wavelength electromagnetic radiation through a medium that also absorbs long-wavelength radiation. This is a property of glass which accounts for the heating effect of greenhouses. It is also a property of carbon dioxide. (Units 28–29)

GROSS PRIMARY PRODUCTION, GPP The total amount of light energy converted by plant photosynthesis to organic chemical energy in organic molecules (in a given area and over a given time). GPP is related to net primary production (NPP) and respiration (R) by the equation $GPP - R = NPP$. (Unit 25)

GROUND STATE OF AN ATOM The state of an atom in which the electrons occupy the lowest possible energy levels. It is therefore the lowest energy state of the atom. (Units 11–12)

GROUP (chemistry) A set of chemical elements, commonly placed in a vertical column in a Periodic Table because of similarities in chemical properties. (Units 13–14)

GUANINE (G) One of the five organic bases that are components of deoxyribonucleotides and ribonucleotides. It has a two-ring structure known as a purine ring system. (Unit 24)

GUYOT See seamount.

H

HABITAT The environment in which an organism normally lives. The habitat is shared by other individuals of the same species (i.e. by a population). There will usually be a community of other populations (i.e. of other species) in the same habitat. (Unit 25)

HADRON A particle that feels the strong interaction and has constituents. A hadron may conveniently be classified according to the value of baryon number B : a meson has zero baryon number $B = 0$, a baryon has $B = 1$, and an antibaryon has $B = -1$. (Unit 32)

HAEM The non-protein part of haemoglobin or myoglobin. Each haem group contains an iron(II) atom and is involved in oxygen transport. Haem is an example of a prosthetic group. (Units 22 and 23)

HAEMATITE An iron oxide mineral with composition Fe_2O_3 . (Units 28–29)

HAEMOCYANIN The respiratory pigment in squid, lobsters, snails and their relatives. (Unit 23)

HAEMOGLOBIN Oxygen-carrying protein present in the red blood cells of many groups of animals, including humans. Each haemoglobin molecule is composed of four polypeptide chains, each with an oxygen-carrying haem group. There are many kinds of normal and abnormal haemoglobin. Haemoglobin A (Hb A) is the normal haemoglobin found in most adult humans. Hae-

hemoglobin S (Hb S) is an abnormal haemoglobin found in the blood of people with sickle cell anaemia and (together with Hb A) in the blood of those heterozygous for the *Hb^S* gene. A molecule of Hb A consists of four polypeptide chains (two α plus two β chains; Hb S consists of two α chains and two abnormal β chains). (Unit 22)

Using the abbreviation Hb for one molecule of haemoglobin, the equation for the reversible formation of oxyhaemoglobin is usually written $\text{Hb} + 4\text{O}_2 \rightleftharpoons \text{HbO}_4$ (oxyhaemoglobin). (Unit 23)

HALF-LIFE For a radioactive sample, the time taken by the sample to lose half of its activity by radioactive decay, that is the time taken for the number of parent isotope atoms to halve. The half-life may be represented by τ in equations of radioactive decay. (Units 11–12 and Units 28–29)

HALOCARBON A compound with molecules containing only atoms of carbon, hydrogen (sometimes), and one or more of the halogens (fluorine, chlorine, bromine and/or iodine). (Units 17–18)

HALOGENS The elements fluorine, chlorine, bromine, iodine and astatine, which are placed in Group VII of Periodic Tables. The family name is derived from the Greek words *hals* (sea-salt) and *gennao* (I produce), because three of the elements (chlorine, bromine and iodine) can be prepared from this source. (Units 13–14)

HAPLOID NUMBER The number of chromosomes found in gametes (reproductive cells). It is half the diploid number. A cell that has the haploid number of chromosomes is said to be haploid. (Unit 20)

HEAT The form of energy that is transferred when two objects at different temperatures are brought into contact. (Unit 9)

HEISENBERG'S UNCERTAINTY PRINCIPLE The product of the uncertainty in a component of the position of a quantum (e.g. Δy) with the uncertainty in the corresponding component of the quantum's momentum at the same time (e.g. Δp_y) is greater than or equal to Planck's constant divided by 4π (e.g. $\Delta y \Delta p_y \geq h/(4\pi)$). (The principle applies to other pairs of variables, for example, energy and time.) (Unit 30)

HELIOCENTRIC MODEL A model of the Solar System according to which the planets orbit the Sun, which is assumed to be stationary. (Unit 1)

HEPATIC PORTAL VEIN Blood vessel that collects blood from the capillaries in the walls of the intestine and carries it direct to the liver. (Unit 23)

HERBIVORE An animal that eats living plants. (Unit 25)

HERITABLE CHARACTERS See inherited characters. (Unit 19)

HERTZ, Hz The unit in which frequency is measured. A frequency of 1 Hz is equivalent to 1 cycle per second, i.e. 1 s^{-1} . (Unit 10)

HESS'S LAW This states that the energy change in a chemical reaction is the same whether the reaction takes place in just one step, or by a number of separate steps whose sum is equal to the one-step process. (Unit 16)

HETEROPOLYMER A type of polymer formed from several different kinds of monomer. (Units 17–18)

HETEROTROPH An organism that obtains the carbon needed for its cellular compounds from organic compounds that it assimilates from the environment. Animals, fungi, and some bacteria are heterotrophs. Heterotrophs normally obtain their energy as well as their carbon from these assimilated organic compounds. In the context of production ecology, heterotrophs are also termed consumers. (Unit 22)

HETEROZYGOSITY (AVERAGE) The average proportion of heterozygous loci per individual within a population. (Unit 21)

HETEROZYGOUS When the members of a homologous pair of chromosomes carry different alleles at a particular locus, the organism is said to be heterozygous for either allele. (Unit 20)

HIGH-ENERGY PHYSICS See particle physics. (Unit 32)

HIGHER CARNIVORE A flesh-eating animal that eats other carnivores. (Unit 25)

HIGHER ORDER STRUCTURE Three-dimensional shape of a protein molecule. The shape is unique for each protein and arises as a consequence of a particular arrangement of weak bonds between residues at various places in the primary structure. Thus the primary structure of a protein (its sequence of amino acid residues) determines the higher-order structure. (Unit 22)

HISTONES Proteins that, together with DNA, make up chromosomes. (Unit 20)

HOMEOSTASIS The maintenance of a stable internal environment in animals and plants. (Unit 23)

HOMINID Any member of the primate family Homiidae, which includes the genus *Homo*. *Homo sapiens* is the only surviving species of the genus. (Units 28–29)

HOMOGENATE A suspension of crushed cells that is still biochemically active. The cell membrane of cells has been broken but the organelles are not damaged. Organelles can be separated from each other and from the cytosol by centrifugation of the homogenate. (Unit 22)

HOMOLOGOUS PAIR OF CHROMOSOMES Each chromosome in a diploid nucleus has a partner, which it resembles closely in physical structure. The two

chromosomes that resemble each other in this way are called a homologous pair. One of the pair is inherited from the mother, the other from the father. (Unit 20)

HOMOLOGOUS SERIES A series of compounds with the same functional group, in which the formula of each member differs from the next by a $-\text{CH}_2-$ group. An example is the series of alcohols CH_3-OH , $\text{CH}_3-\text{CH}_2-\text{OH}$, $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{OH}$, etc. (Units 17–18)

HOMOPOLYMER A type of polymer formed from a single kind of monomer. (Units 17–18)

HOMOZYGOUS When the members of a homologous pair of chromosomes carry the same allele at a particular locus, the organism is said to be homozygous for that allele. (Unit 20)

HORMONE A chemical messenger produced in very small quantities in one part of an organism and transported to the target tissue where it exerts its effect. (Unit 23)

HUND'S RULE An empirical rule that requires that within any subshell in an atom in its ground state, a maximum number of electrons are unpaired. (Units 11–12)

HUYGENS' CONSTRUCTION Every point on a wave's wavefront can be thought of as a point-source of secondary circular (or, in three dimensions, spherical) waves that each have the same speed and wavelength as the original wave. Subsequent wavefronts of the original wave can then be found by the superposition of all these secondary waves. (Unit 10)

HYDROCARBON A compound with molecules containing only carbon atoms and hydrogen atoms. (Units 17–18)

HYDROCARBON GROUP A term used to distinguish the relatively unreactive part of a carbon compound, e.g. an alkyl group. Strictly, an alkyl group is a saturated hydrocarbon group; it is also possible to have unsaturated hydrocarbon groups containing carbon-carbon double or triple bonds. (Units 17–18)

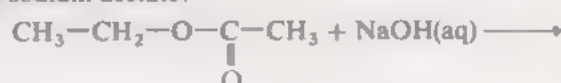
HYDROGEN BONDS A particularly important type of intermolecular attraction, weaker than the covalent bonds within molecules but stronger than dipole-dipole forces or London forces. Hydrogen bonds in organic compounds occur between hydrogen atoms that are attached to oxygen or nitrogen atoms, and oxygen or nitrogen atoms in an adjacent molecule. (Units 17–18)

Hydrogen bonds are important in the structures of several biopolymers, including proteins and nucleic acids. The two strands of the DNA double helix are held together by hydrogen bonds between complementary bases: A pairs with T via two hydrogen bonds and G pairs with C via three hydrogen bonds. (Unit 24)

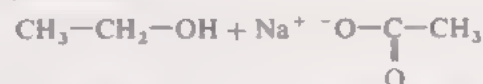
HYDROLOGICAL CYCLE The water cycle; the sequence of events in which water is evaporated from

the oceans, deposited on land as rain, hail or snow, and carried by rivers to the sea, where it is evaporated again. (Unit 27)

HYDROLYSIS Literally, breaking down (lysis) by water. A reaction in which a molecule (often an ester or an amide) is broken down into two or more smaller molecules through the addition of the equivalent of one or more water molecules. Frequently, the use of an acid or an aqueous solution of a base is used to speed up the reaction. (If a base is used one of the products from hydrolysis of an ester or an amide is not a carboxylic acid but its salt.) An example is the hydrolysis of ethyl acetate by aqueous sodium hydroxide to give ethanol and sodium acetate.



ethyl acetate



ethanol

sodium acetate

Hydrolytic reactions occur widely in biology, e.g. in digestion of food (proteins, fats and polysaccharides). (Units 17–18)

HYDROSPHERE The total body of water of the Earth (including the oceans, rivers, lakes, and water in the atmosphere). (Units 28–29)

HYDROXYL GROUP A group with the formula $-\text{OH}$ that has one spare valency. It can be thought of as a water molecule (H_2O) from which one hydrogen atom has been removed. (Units 17–18)

HYPERGLYCAEMIA A high level of glucose in the blood. The opposite state is hypoglycaemia. (Unit 23)

HYPOGLYCAEMIA A low level of glucose in the blood. The opposite state is hyperglycaemia. (Unit 23)

HYPOTENUSE The side facing the right angle in a right-angled triangle. (Unit 2)

HYPOTHALAMUS Region of the brain that is responsible for the maintenance of a stable temperature in mammals. It is situated at the base of the brain close to the pituitary gland. (Unit 23)

ICE AGE Repeated periods of glaciation during which a large part of the Earth is covered in ice (synonymous with glacial period). (Units 28–29)

IGNEOUS ROCKS Rocks formed by the cooling and crystallization of magma (*ignis* is the Latin for fire). They are characterized by an interlocking crystalline texture, and can be coarse-grained if intruded and cooled slowly or fine-grained if they erupt and are cooled quickly. (Units 5–6)

All igneous rocks can be derived from mantle peridotite through processes involved in the rock cycle. (Unit 27)

INDEPENDENT ASSORTMENT When chromosomes align themselves along the equator of the cell during metaphase, each homologous pair aligns itself quite independently of every other pair. This is called independent assortment. Since genes are carried on chromosomes, their behaviour follows that of the chromosomes. (Unit 20)

INDEPENDENT VARIABLE In an experiment (or calculation), the quantity whose value is set by the experimenter. On graphs, it is conventional to plot the independent variable along the horizontal axis. (Unit 4)

INDICATOR A substance whose colour changes when the hydrogen ion concentration of an aqueous solution placed in contact with it is altered. (Unit 15)

INDUCED NUCLEAR FISSION A process in which an atomic nucleus is induced by an external agency to undergo fission. (Unit 31)

INHERITED CHARACTERS Characters that are passed on from generation to generation by inheritance. (Unit 19)

INITIATOR A substance that on heating readily forms radicals, which in the presence of appropriate monomer molecules (that is, ones containing a double bond) initiate addition polymerization. (Units 17–18)

INITIATOR CODON The sequence of bases AUG found at the beginning of all mRNA molecules. During translation, it initiates the synthesis of all polypeptides, hence its name. It also codes for methionine, and therefore all newly formed polypeptides begin with a methionine residue—though this is often removed by post-translational modifications. (In some viruses and in mitochondria, however, other initiator codons are found as well as AUG.) (Unit 24)

INNER CORE The innermost part of the Earth, which forms a sphere with a radius of about 1 215 km; it is solid and thought to be composed of an iron–nickel mixture in which iron is by far the more abundant metal. (Units 5–6)

INORGANIC PHOSPHATE, P_i This anion is important in the interconversion of ATP and ADP: $ATP \rightleftharpoons ADP + P_i$. (Unit 22)

INSTANTANEOUS SPEED The speed of an object at a particular instant of time. (Unit 3)

INSULIN A protein hormone (produced in the pancreas) that has a key role in the regulation of the concentration of glucose in blood. The insulin molecule contains two different polypeptide chains, A and B, linked by disulphide bridges. (Units 22 and 23)

INTENSITY OF AN EARTHQUAKE A measure of the effect of an earthquake by observed phenomena, for example damage to buildings or visible movement of objects. Earthquake intensity is measured on the Mercalli scale (I–XII). (Units 5–6)

INTENSITY OF RADIATION For a beam of radiation, the intensity of the beam is the amount of energy carried in unit time across unit area perpendicular to the direction of motion. (Unit 10)

INTERCEPT The point on a graph at which the line cuts an axis. On a plot of y against x , for example, the intercept on the y axis corresponds to the value of y at $x = 0$. (Unit 4)

INTERGLACIAL DEPOSIT Sediments deposited during the intervals between periods of glaciation. (Units 28–29)

INTERMEDIATE (biology) In metabolic pathways, substances formed from initial reactant(s) and ultimately converted into final product(s) are called intermediates. For example, in glycolysis the conversion of glucose into pyruvic acid occurs via a sequence of C_6 and C_3 intermediates. (Unit 22)

INTERMEDIATE VECTOR BOSON The type of gauge boson that mediates weak interactions. There are three intermediate vector bosons—the W^+ , the W^- and the Z —and each has been observed with approximately the rest mass predicted by the Weinberg Salam theory of weak and electromagnetic interactions. (Unit 32)

INTERMOLECULAR FORCES The forces between molecules that bind them together in the liquid or solid states. There are three main types: hydrogen bonds, dipole–dipole forces, and London forces. (Units 17–18)

INTERNAL ENERGY The form of energy stored in the atoms of a substance and associated with their interactions and random motion. It is not possible to measure an absolute value for the internal energy of a system in any particular state: the significant quantity is the change in internal energy. A rise in the temperature of a system always corresponds to an increase in its internal energy (but note that the converse is not always true if a change of state is involved). (Unit 9)

INTERPOLATION The process of reading between data points on a graph, in order to find pairs of values at intermediate points for the two quantities plotted (cf. extrapolation). (Unit 4)

INTRONS Non-coding sequences of bases in a split gene. These are transcribed into an mRNA molecule, together with the coding exon sequences. The transcribed intron sequences are 'tailored' out and the remaining transcribed exon sequences 'spliced' together to make an mRNA molecule that can be translated to make a functional protein. (Unit 24)

INTRUSIVE The term used to describe an igneous rock that is formed by cooling and crystallization of

magma within the crust or mantle. The magma may rise from the site of melting to higher levels before crystallization takes place, because it is less dense than the surrounding material. Intrusive rocks, such as granite and gabbro, cool slowly and are characterized by a coarse grain size; they are also called plutonic rocks. (Units 5–6)

IN VITRO Literally, 'in glass'. The term is widely used to describe experimental arrangements in which a biochemical or physiological process takes place outside the living organism (cf. *in vivo*). (Unit 22)

IN VIVO Literally, 'in life'. The description is applied to biochemical or physiological processes occurring within the intact organism (cf. *in vitro*). (Unit 22)

ION An atom or molecule that has lost or gained one or more electrons, leaving it with a positive or negative charge, respectively (e.g. Na^+ and F^-). (Units 11–12)

IONIC BONDING A model of chemical bonding in which appropriate chemical substances are regarded as collections of ions, the principal binding forces being the attraction between unlike charges. (Units 13–14)

IONIC INTERACTIONS One class of the weak bonds important in the higher-order structure of proteins. Such bonds occur when a negatively charged R group of one amino acid residue in one part of a polypeptide chain is electrostatically attracted to a positively charged R group of another amino acid residue in another part of the polypeptide chain. The pH affects enzyme activity via variation in the charge of such R groups. (Unit 22)

IONIC SUBSTANCE A substance whose properties are such that it can be usefully thought of as a collection of ions held together by the attractive forces between unlike charges. (Units 13–14)

IONIZATION ENERGY, I The energy required to remove an electron from an atom or ion. (Units 11–12)

IONIZING RADIATION The products of radioactive decays (and other reactions) that can ionize matter. The types of ionizing radiation include X-rays, α - and β -particles, γ -radiation and neutrons. (Unit 31)

ION PRODUCT OF WATER The product of the concentrations of aqueous hydrogen and hydroxide ions in an aqueous solution at equilibrium. At 25°C , it has the value $1.0 \times 10^{-14} \text{ mol}^2 \text{ l}^{-2}$. (Unit 15)

IRON METEORITES Fragments of metallic material that have arrived at the Earth's surface from a Sun-centred orbit in the asteroid belt and are thought to represent core material from broken-up Earth-like planets. (Units 5–6)

These meteorites are composed almost entirely of nickel-iron alloy, although sulphur may also be present. (Units 28–29)

ISLAND ARC The chain of volcanic islands that builds up on oceanic crust above the subduction zone at an ocean/ocean destructive plate margin. (Units 7–8)

ISOMERS Different molecules are isomers if they have the same molecular formula but differ in the arrangement of their atoms. See *cis*, functional, geometric, optical, position, skeletal, stereo, structural and *trans* isomers.

ISOSTASY The process by which the Earth's crust adjusts by vertical movements (a process called isostatic readjustment) to addition or removal of crustal material, so as to eliminate gravity anomalies by attaining a state of isostatic equilibrium. (Units 7–8)

ISOTOPE Isotopes are atoms of the same element (so they all have the same atomic number) but with different mass numbers (because there are different numbers of neutrons in the nuclei). (Units 11–12 and 31)

ISOTOPIC LABELLING By incorporating an unusual isotope of a particular atom (e.g. ^{14}C) into the molecule of the desired compound, the metabolic fate of that molecule can be followed. (Unit 22)

J

JOINTS (Earth sciences) Well-defined patterns of cracks in rocks. In extrusive igneous rocks, particularly when the lava flow is thick, joints may be caused by shrinkage on cooling, and are often in a polygonal pattern. In sedimentary rocks, joints are perpendicular to bedding planes. (Unit 27)

JOULE, J The SI unit of energy. One joule is defined as the amount of energy transferred when the point of application of a constant force of one newton moves a distance of one metre in the direction of the force: $1 \text{ J} = 1 \text{ N m} = 1 \text{ kg m}^2 \text{ s}^{-2}$. (Unit 9)

K

KARYOTYPE The complete collection of chromosomes in each cell of an individual. (Unit 20)

KELVIN, K The SI unit of temperature. The temperature of an object in kelvin is related to its temperature in degrees Celsius by the expression: temperature in kelvin = temperature in degrees Celsius + 273.15. (Unit 9)

KEPLER'S FIRST LAW This states that the planets of the Solar System orbit the Sun in elliptical paths. The Sun is at one focus of each of these elliptical orbits. (Unit 2)

KEPLER'S SECOND LAW This states that in the Solar System, the 'spoke' joining the Sun to a planet sweeps out equal areas in equal times. (Unit 2)

KEPLER'S THIRD LAW This states that in any given system of orbiting bodies, the square of each body's orbital period divided by the cube of that body's orbital radius is a constant, i.e. $T^2/R^3 = \text{constant}$. (Unit 2)

KETONE A compound with molecules in which a carbonyl group ($\text{C}=\text{O}$) is attached to two hydrocarbon groups. If the hydrocarbon groups are saturated, the systematic name of a member of this class of compounds is alkanone. (Units 17–18)

KEY MORTALITY FACTOR The mortality factor whose pattern of annual variation in k -value most closely parallels that of the annual variation of k_{total} (the total generation pre-reproductive mortality). It usually makes the largest contribution to the value of k_{total} . The key mortality factor is rarely density dependent. (Unit 25)

KILOGRAM, kg The SI unit of mass. (Unit 2)

KINETIC ENERGY The energy an object possesses by virtue of its motion. An object of mass m moving with speed v has a kinetic energy of $\frac{1}{2}mv^2$. (Unit 9)

KINGDOM (biology) The largest taxonomic category: several phyla form one kingdom. The scheme of classification used in S102 divides all species into four kingdoms: animals, green plants, fungi, and prokaryotes. (Unit 21)

k -VALUE An arithmetic device for expressing the killing power of a particular mortality factor. It is the logarithm to the base ten of the ratio of the number of individuals alive before a particular mortality factor has operated to the number of individuals surviving after the mortality factor has operated, viz. $k = \log_{10}(N_B/N_A)$. (Unit 25)

k -VALUE ANALYSIS A survey of k -value data that helps one understand why population densities change in the way that they do. (Unit 25)

L

LACTATE DEHYDROGENASE The enzyme that catalyses the reversible reaction between pyruvic acid and NADH_2 to give lactic acid and NAD. (Unit 22)

LACTIC ACID The compound produced when pyruvic acid is reduced by NADH_2 , a reaction that occurs during anaerobic catabolism in muscle. At cellular pH, lactic acid is ionized to lactate ions. Biochemists often use 'lactic acid' and 'lactate' interchangeably. (Unit 22)

LANTHANIDES A set of 14 chemical elements, defined in this Course as the series of elements from La to Yb (numbers 57–70) inclusive. They resemble each other closely, and span a region of atomic number in which the 4f shell in the free atoms is being filled. (Units 13–14)

LARVA The stage in the life cycle of an insect from the time it leaves the egg until it changes into a pupa. (Unit 25)

LAVA Hot molten rock (magma) extruded at the surface of the Earth, often of basaltic composition. The term is also used for the solid material formed in this way. (Units 5–6)

LAVA FLOW Magma that has been extruded onto the Earth's surface, and has flowed downhill under the force of gravity. (Units 5–6)

LE CHATELIER'S PRINCIPLE This states that when a system in equilibrium is subjected to an external constraint, the system responds in a way that tends to lessen the effect of the constraint. (Unit 15)

LEPTON Leptons do not feel the strong interaction, but they feel the gravitational and weak interactions (charged leptons also interact electromagnetically.) There are known to exist several varieties of lepton (e.g. the electron and its associated neutrino). Each lepton is currently believed to be a fundamental particle. (Unit 32)

LEPTON-QUARK SYMMETRY According to this symmetry, the number of pairs of leptons (one with charge -1 , the other with charge 0) is equal to the number of pairs of quarks (one with charge $+\frac{2}{3}$, the other with charge $-\frac{1}{3}$). This symmetry implies that the number of varieties of leptons is equal to the number of varieties of quarks. (Unit 32)

LEWIS STRUCTURE A diagram, named after G. N. Lewis, which shows how the outer electrons of the atoms in a chemical substance are shared to create electron-pair bonds, in accordance with the theory of covalent bonding. (Units 13–14)

LIFE TABLE A table or chart that shows how the size of a population (or the percentage of an initial population that survives) decreases with time. If values are expressed in percentage terms, a full life table will begin at 100% and end at 0%. Sometimes it shows the causes of death (mortality factors). (Unit 25)

LIGHT ENERGY The form of energy associated with visible light. (Unit 9)

LIGHT STAGE OF PHOTOSYNTHESIS This is the part of photosynthesis concerned with the formation of NADPH_2 from NADP and water, and of ATP from ADP and P_i , with the consequent production of oxygen. The energy necessary is supplied by light absorbed by the chlorophyll molecules in the layers of membranes within chloroplasts. The products of the light stage (NADPH_2 and ATP) are used in the dark stage. (Unit 22)

LIMESTONE A sedimentary rock, composed largely of calcium carbonate, that is typically formed by the accumulation on the sea-bed of former marine organisms. It can also be formed by the direct precipitation of carbonate mud. (Units 5–6 and 27)

LINEAR ACCELERATOR A device that accelerates charged particles in a straight line. (Unit 32)

LINEAR MAGNETIC ANOMALY Elongated magnetic anomalies, generally located parallel to extinct or active ocean ridges. (Units 7–8)

LINE SPECTRUM OF AN ATOM A spectrum that consists of electromagnetic radiation of particular wavelengths. These lines are produced by electrons making transitions between energy levels of the atom. (Units 11–12)

LINKAGE GROUP The cluster of genes carried on the same chromosome. During meiosis they remain together except when separated by crossing over. (Unit 20)

LINK REACTION A complex catabolic reaction that occurs in the mitochondrial matrix, so called because it 'links' glycolysis with the tricarboxylic acid (TCA) cycle. In the link reaction, pyruvic acid (from glycolysis) is converted into acetyl CoA (which is then further catabolized via the TCA cycle). For each molecule of acetyl CoA produced by the link reaction one molecule of carbon dioxide and one molecule of NADH_2 are also produced. (Unit 22)

LIPASE An enzyme that catalyses the hydrolysis of fats to fatty acids and glycerol. (Unit 22)

LITHOSPHERE The outer part of the Earth, above the asthenosphere, which is essentially rigid. It includes the Earth's crust, both oceanic and continental, and the part of the upper mantle down to about 100 km. (Units 7–8)

LITTER See detritus.

LOCK AND KEY MODEL The model of enzyme action that supposes that the shape of the active site of an enzyme matches the shape of the substrate which binds to it. Although there are sophisticated variants of the model, experimental evidence shows that the idea of 'a good fit' between substrate and active site is largely true. (Unit 22)

LOCUS (biology) The location of a gene on a chromosome. (Unit 20)

LODESTONE A naturally occurring magnetic rock. (Units 5–6)

LOGARITHMIC SCALE A scale of numbers in which an increase in the actual magnitude of a quantity by a factor of 10 (an order of magnitude) causes an increase on the logarithmic scale by one unit. (Units 5–6)

LOGARITHM TO THE BASE TEN Any positive number has a logarithm to the base ten. It is the power to which 10 must be raised in order to make it equal to the number in question. If the number is x then the logarithm to the base ten (\log_{10} or \log) is y , where $10^y = x$. (Unit 15)

LONDON FORCES The cohesive forces between all molecules in the liquid or solid states (including those that do not have permanent dipolar bonds). Instantaneous dipoles arise from the transient separation of positive charge and negative charge, due to circulation of the valence electrons. This results in a net attractive force even when, on average, the electrons are evenly distributed. Sometimes known as van der Waals forces. (Units 17–18)

LONG PERIOD Any one of the Periods 4 to 7 in the Periodic Table shown in Figure 17 of Units 13–14. These Periods contain not only typical elements, but also transition elements and, in some cases, lanthanides or actinides as well. (Units 13–14)

LOWER MANTLE The part of the mantle that lies between the base of the transition zone at 1 050 km and the core–mantle boundary at 2 900 km. (Units 5–6)

LOW-SPEED LAYER The part of the upper mantle within which the speeds of seismic waves are comparatively low owing to the presence of a partially molten component. Commonly referred to by Earth scientists as low-velocity zone. The depth and thickness of the layer vary around the Earth but, in general, it lies at depths of between 50 and 250 km. (Units 5–6)

LUNAR PHASES, CYCLE OF The periodic cycle of the phases of the Moon, as observed from the Earth. The changes in the appearance of the Moon correspond to the changes in the time of day or night during which the Moon can be seen above the horizon. (Unit 1)

LUSTRE The 'shine' of a mineral. The lustre may be described as glassy, silky, metallic or earthy, for example. (Unit 27)

M

MACROMOLECULE A general name for a very large ('giant') molecule, often used interchangeably with the more specific term polymer. (Units 17–18)

MAGMA Hot molten rock. It can often contain dissolved water and gases that are released when the magma solidifies. See lava. (Units 5–6)

MAGNETIC ANOMALY The amount by which the measured magnetic field strength at any place differs from the field strength that is expected at that point from the model of the field involving the dipole and non-dipole components. (Units 7–8)

MAGNETIC DECLINATION The angle between the directions of the geomagnetic pole in the Northern Hemisphere and geographic north, measured in degrees east or west of true (geographic) north. (Units 5–6)

MAGNETIC DIPOLE A magnet (such as a normal bar magnet) with two poles which produces a magnetic field that is symmetrical about the axis of the dipole. (Units 5–6)

MAGNETIC DIP POLES The places on the Earth's surface where the total (observed) magnetic field is vertical. In other words the magnetic inclination is 90° (i.e. vertical). (Units 5–6)

MAGNETIC FIELD The field of force associated with the magnetism of a magnetic object such as a bar magnet. (Units 5–6)

MAGNETIC INCLINATION The angle that a suspended compass needle, free to rotate in a vertical plane, makes with respect to the horizontal. This is defined as positive if the north pole of the needle dips below the horizontal and negative if it rises above the horizontal. (Units 5–6)

MAGNETIC PROSPECTING A technique that uses a magnetometer to measure the strength of the magnetic field over a large area, so that zones of magnetic rocks can be located. (Units 5–6)

MAGNETIC QUANTUM NUMBER, m_l The quantum number that is used to label degenerate energy levels within a subshell in an atom. m_l may have values from $-l$ to $+l$, where l is the second quantum number. (Units 11–12)

MAGNETIC SPIN QUANTUM NUMBER, m_s The quantum number that denotes the alignment of the electron spin; m_s can have the values $\pm \frac{1}{2}$. (Units 11–12)

MAGNETOMETER An instrument used for measuring the strength of a magnetic field. (Units 5–6)

MAGNITUDE OF AN EARTHQUAKE The maximum amount of ground motion caused by an earthquake, measured using a standard calibrated seismometer (cf. Richter scale). (Units 5–6)

MAGNITUDE OF A QUANTITY The value of a quantity, with its associated units, preceded by a (usually implied) positive sign. Denoted by vertical rules on either side of the quantity. For example, if $x = -10$ units, the magnitude of the quantity is $|x| = 10$ units. (Unit 3)

MAIN GROUP ELEMENTS See typical elements. (Units 13–14)

MAINTENANCE (biology) Production of new cells and cell chemicals to replace those broken down in turnover occurring in tissues. (Unit 22)

MANTLE The part of the Earth's interior that lies beneath the Mohorovičić discontinuity at a depth of between 6 km and 90 km, and above the core–mantle boundary at a depth of 2900 km. The mantle is predominantly of peridotitic composition, though the structure and state of compression of the material vary with depth. (Units 5–6)

MANTLE PLUME Region of high heat flow in the upper mantle that is located away from a constructive plate margin. (Units 7–8)

MARKER HORIZON A distinctive bed in a sedimentary or volcanic rock that can be recognized in more than one locality. (Units 28–29)

MASS A property of an object that describes either its inertia or the magnitude of the gravitational attraction it will exert on other objects (see also force and Newton's second law). These ways of interpreting mass are (at present) believed to be equivalent. The SI unit of mass is the kilogram, kg. (Unit 3)

MASS NUMBER, A The number of protons and neutrons in the nucleus of an atom. It has the value of the relative atomic mass (A_r) for the isotope, rounded to the nearest integer. (Units 11–12 and 31)

MASS SPECTROMETER An instrument that separates atoms (as ions) according to their mass, and enables the mass of an atom to be determined. (Units 11–12)

MASS SPECTRUM A plot of the intensity of ion current against the mass-to-charge ratio of an ion. A mass spectrum thus indicates the presence of ions of different mass-to-charge ratios and indicates their relative abundances. (Units 11–12)

MAXIMUM VALENCY The highest valency exercised by an element in any of its known compounds. It is usually so exercised in compounds of the element with oxygen or fluorine. (Units 13–14)

MEDULLA The central part of an organ or tissue. In particular, the term is applied to part of the brain of vertebrates. It contains centres for control of breathing and heart beat. The term medulla is also applied to the inner tissue layer of the adrenal glands. (Unit 23)

MEIOSIS The type of cell division that results in a halving of the number of chromosomes in the nucleus, and that is a necessary prelude to the formation of gametes. Each of the two divisions in meiosis is subdivided into stages; division I: prophase I, metaphase I, anaphase I, telophase I; division II: prophase II, metaphase II, anaphase II, telophase II. (Unit 20)

MERCALLI SCALE A scale of earthquake intensity from I to XII that uses damage to buildings, roads and railways as the main criterion. (Units 5–6)

MESELSON AND STAHL EXPERIMENT The experiment that confirmed the model of semi-conservative replication of DNA. (Unit 24)

MESON A hadron that has zero baryon number, $B = 0$. According to the simple quark model, each meson consists of a quark and an antiquark. (Unit 32)

MESSANGER RNA, mRNA A single-stranded molecule of RNA produced by the transcription of DNA. A given molecule of mRNA carries a code for the sequence of amino acids that make a particular polypeptide. (Unit 24)

METABOLIC PATHWAY A sequence of biochemical reactions via which some overall anabolic or catabolic process occurs. The many different and interlinked pathways constitute metabolism as a whole. (Unit 22)

METABOLISM The sum of catabolism and anabolism (plus any other biochemical reactions that do not fit easily into either of these categories). (Unit 22)

METABOLITE Any constituent of a metabolic pathway. (Unit 22)

METALLIC BONDING The type of chemical bonding that holds metals together. In this Course, metals are modelled by an array of positive ions immersed in a pool of free electrons, and the bonding arises from electrostatic attraction between the ions and the intervening electrons. (Units 13–14)

METALS A class of chemical substances to which most chemical elements belong. They are good conductors of heat and electricity in the solid and liquid states, their electrical conductivity decreases with increasing temperature, and bulk samples often have a lustrous appearance. (Units 13–14)

METAMORPHIC GRADE The degree of metamorphism that a metamorphic process has reached; broadly, low grade involves low temperatures and pressures and high grade involves high temperatures and pressures. (Unit 27)

METAMORPHIC ROCKS Rocks that have had their texture and/or mineralogy changed by the action of heat and/or pressure (usually both are involved). Metamorphic rocks can be derived from sedimentary or igneous rocks (or pre-existing metamorphic rocks). They have an interlocking crystalline texture and often display some form of mineral alignment or banding. (Unit 27)

METAMORPHISM (Earth sciences) From the Greek for 'changing form'; metamorphism is the process involved in changing the texture and mineralogy of existing rocks (sedimentary, igneous, or metamorphic) into metamorphic rocks, by heat and pressure. (Unit 27)

METAPHASE See meiosis and mitosis

METAZOA The largest subkingdom of the animal kingdom: it includes all animals except the sponges and single-celled animals. (Units 28–29)

METEORIC WATER Surface water (rainwater, river water, etc.) that penetrates rocks from above. (Units 28–29)

METEORITE Extraterrestrial material that falls to the surface of the Earth. Meteorites are classified as stony, iron, and stony-iron. (Units 28–29)

METHYL GROUP The simplest hydrocarbon group, consisting of a single carbon atom with three hydrogen

atoms attached and one free valency, and usually abbreviated as CH_3- or $-\text{CH}_3$. (Units 17–18)

METRE, m The SI unit of length. (Unit 2)

MICA A group of hydrated, aluminium silicate minerals. The most important members are biotite, which is rich in iron and magnesium and brown in colour, and muscovite, which is poor in iron and magnesium and is white or colourless. Micas have perfect cleavage in one direction, a reflection of their sheet structure at the atomic level. Their hardness is about that of a fingernail. (Unit 27)

MILLIGAL The (non-SI) unit of acceleration traditionally used in gravity survey work, defined as a thousandth of a gal. (A gal is defined as an acceleration of 10^{-2}ms^{-2} .) A milligal is $1 \times 10^{-5} \text{ms}^{-2}$, which is approximately a millionth of the value of g , the magnitude of the acceleration due to gravity on the Earth's surface. (Units 7–8)

MINERAL A naturally occurring chemical element or compound possessing a definite crystalline structure that is based on an ordered internal arrangement of the constituent atoms, and with a chemical composition that may be expressed in terms of a formula. (Unit 27)

MINERAL CYCLE The localized cycle (i.e. within an ecosystem) of a mineral element between living and non-living parts of the natural world. Mineral cycling does not involve the atmosphere. Mineral elements are so-called because their main reservoir is in (mineral) rocks. (Unit 25)

MITOCHONDRIA (singular mitochondrion) Small subcellular organelles concerned with oxidative catabolism. They contain, among others, the enzymes of the link reaction, the tricarboxylic acid cycle, the β -oxidation pathway and the electron transport chain. As they are the principal ATP-making organelles, mitochondria are often termed the powerhouses of the cell. (Unit 22)

MITOSIS The type of cell division that takes place during growth and during the repair of parts of the body. Mitosis produces diploid cells each with a set of chromosomes identical with that possessed by the parent cell. Mitosis occurs in a sequence of stages, termed prophase, metaphase, anaphase and telophase. (Unit 20)

MODEL An artificial construction invented to represent or to simulate the properties, the behaviour, or the relationship between individual parts of the real entity being studied. (Unit 1)

MOHOROVIČIĆ DISCONTINUITY (MOHO) The seismic boundary between the crust and the mantle. (Units 5–6)

MOLAR MASS, M The mass of one mole of a substance. (Units 13–14)

MOLE A unit of the amount of chemical substance. Any pure chemical substance can be represented by a chemical formula, which can be read as a collection of atoms called a formula unit. Thus, magnesium fluoride can be represented by the chemical formula MgF_2 , and the formula unit contains one magnesium atom and two fluorine atoms. A mole is the amount of a substance that contains the same number of formula units as the number of atoms in 12 g of the ^{12}C isotope of carbon. It turns out that 12 g of ^{12}C contain 6.022×10^{23} atoms of ^{12}C . So, for example, one mole of MgF_2 contains 6.022×10^{23} magnesium atoms and 12.044×10^{23} fluorine atoms. A mole of substance is usually expressed as a mass in grams, the number of grams being obtained by adding together the relative atomic masses of the atoms in the formula unit. The relative atomic mass of magnesium is 24.3, and of fluorine is 19.0. Thus, one mole of MgF_2 has a mass of $(24.3 + 2 \times 19.0)$ g, or approximately 62.3 g. (Units 13–14)

MOLECULAR COVALENT SUBSTANCE A substance whose properties are such that it can be usefully thought of as a collection of discrete molecules, the binding within the molecule itself being strong and covalent, and the binding between molecules being weak. (Units 13–14)

MOLECULAR FORMULA A representation using chemical symbols of the atoms contained in one molecule of a covalent compound. (Units 13–14)

The molecular formula gives the types of atom, and the number of each, in a molecule. For example, the molecular formula of ethanol, for which the abbreviated structural formula is $\text{CH}_3\text{—CH}_2\text{—OH}$, is $\text{C}_2\text{H}_6\text{O}$. By convention, the molecular formulae of carbon compounds are always written in the order C, H, then the other elements present in alphabetical order. (Units 17–18)

MOLECULE A group of atoms bound together by covalent bonds. The numbers of atoms within a molecule are represented by the molecular formula, e.g. a molecule of methane contains one atom of carbon and four atoms of hydrogen, and is represented by CH_4 . (Units 13–14)

MOMENTUM The product of an object's mass and its velocity. A momentum is fully specified only if both its magnitude and its direction are specified. For a number of interacting objects not subjected to unbalanced forces, the total momentum is conserved. (Unit 3)

MONITOR The part of a control system that compares the output from a receptor with a reference and, if there is a difference, initiates an effector to restore the reference level. (Unit 23)

MONOMER A compound with molecules that, under the correct conditions, can link to form larger molecules called polymers. (Units 17–18)

MONOSACCHARIDE A sugar that cannot be hydrolysed to anything simpler. Examples are glucose, fructose and ribose. (Unit 22)

MORPHOLOGY The structure and appearance of an organism. (Unit 19)

MORTALITY FACTOR A particular 'cause of death'. In a given life history, there are usually several kinds of mortality factor operating in a sequence. Each mortality factor has its own *k*-value. See life table. (Unit 25)

MORTALITY RATE The percentage or proportion of a population that has been killed or has died. Sometimes 'mortality' is used to mean mortality rate. (Unit 25)

MOTOR NERVE A nerve made up of neurons that stimulate effector organs. (Unit 23)

MOUNTAIN BELTS Linear, high altitude parts of the Earth's crust, such as the Alpine-Himalaya belt (also known as mountain chains). (Units 7–8)

mRNA See messenger RNA. (Unit 24)

MUDSTONE (MUDROCK) Fine-grained, usually dark-coloured sedimentary rocks, formed by the compaction of clay particles. (Units 5–6)

MULTICELLULAR Description of an organism consisting of many cells. All multicellular organisms are eukaryotic. (Unit 19)

MUSCULAR WORK When muscles contract they impart kinetic or gravitational energy to the organism or to external objects—thus they are said to do work. The energy for this is supplied by the conversion of ATP to ADP and P_i . (Unit 22)

MUTANT An organism that possesses a mutation. (Unit 19)

MUTATION A change in an inherited character. (Unit 19)

More precisely, it is the alteration, deletion or insertion of a single base (or sequence of bases) in a DNA molecule. Mutations are caused by chemically induced or radiation-induced changes in the DNA. (Unit 24)

MUTATION RATE The frequency (per generation) with which one allele is formed by mutation, instead of the normal allele. (Unit 21)

MYOGLOBIN An oxygen-carrying protein found in muscles. Each myoglobin molecule consists of a single polypeptide chain to which a haem prosthetic group is attached. (Unit 22)

N

NAD (nicotinamide adenine dinucleotide) A hydrogen-carrying coenzyme. Its reduced form is written as NADH_2 . It is produced in many catabolic pathways (e.g. glycolysis, the link reaction, the tricarboxylic acid cycle, and the β -oxidation pathway) and is

reoxidized by the electron transport chain. For each molecule of NADH_2 oxidized, three molecules of ATP are made. (Unit 22)

NADP (nicotinamide adenine dinucleotide phosphate) A hydrogen-carrying coenzyme. Its reduced form is written as NADPH_2 . It is involved in many pathways: the light and dark stages of photosynthesis are important examples. (Unit 22)

NAKED BOTTOM (physics) A hadron that has non-zero bottomness. (Unit 32)

NAKED CHARM A hadron with non-zero charm is said to have naked charm. (Unit 32)

NATALITY RATE An expression of birth rate in terms of the number born per year as a percentage or proportion of a population. Sometimes 'natality' is used to mean natality rate. (Unit 25)

NATURAL CLASSIFICATION Though there are several different schemes by which species are categorized, the intention is that natural classification should reflect the evolutionary relationships of species. (Unit 21)

NATURAL SELECTION The process that, according to Darwinism, brings about the evolution of new species of animals and plants. Organisms that are fitter (because they are better adapted to their environment and survive better to reproduce) are naturally selected. See also adaptation. (Unit 19)

NEBULA A diffuse cloud of dust particles and gases. (Units 28–29)

NEBULAR THEORY A theory for the origin of the Solar System. It proposes that the Sun and the planets contracted and condensed from a spinning disc of gas and dust (cf. catastrophic-event theory). (Units 28–29)

NEGATIVE FEEDBACK The process by which a control mechanism reacts to a change in the output of the system by initiating a restoring action. Negative feedback systems maintain a preset state, so they are stable. Such systems are important in both biochemistry and physiology (cf. positive feedback). (Units 22 and 23)

NET PRIMARY PRODUCTION, NPP That part of the gross primary production (GPP) that remains after plants have used some of the GPP in respiration (R). So, $NPP = GPP - R$ (usually expressed in $\text{kJ m}^{-2} \text{yr}^{-1}$). NPP may increase plant biomass, be consumed by herbivores or (after death) pass to decomposers and detritivores. (Unit 25)

NEURON The basic cell of the nervous system. It is able to transmit electrical impulses that can encode information. (Unit 23)

NEUTRALIZATION The mutual destruction of an acid and a base in a chemical reaction that takes place in aqueous solution. (Unit 15)

NEUTRAL SOLUTION An aqueous solution in which the concentrations of aqueous hydrogen and hydroxide ions are equal. At 25°C their concentrations are each $1.0 \times 10^{-7} \text{ mol l}^{-1}$. (Unit 15)

NEUTRINO A lepton that has zero charge and zero (or nearly zero) rest mass. A different type of neutrino is associated with each type of charged lepton. (Unit 32)

NEUTRON A particle with no electric charge and a relative mass very close to one on the scale of relative atomic mass. Neutrons exist in atomic nuclei. (Units 11–12)

NEWTON, N The SI unit of force. $1 N = 1 \text{ kg m s}^{-2}$. (Unit 3)

NEWTONIAN MECHANICS See classical mechanics. (Unit 3)

NEWTON'S FIRST LAW OF MOTION This states that every object continues in a state of motion with constant velocity unless acted on by unbalanced forces. (If the object is initially at rest, this velocity is zero.) (Unit 3)

NEWTON'S LAW OF GRAVITATION This states that a mass attracts another mass with a force whose magnitude is directly proportional to the product of the two masses and inversely proportional to the square of the separation of their centres. The force of attraction between two masses m_1 and m_2 whose centres are separated by a distance d is of magnitude $F = Gm_1m_2/d^2$, where G is the gravitational constant. The attractive force acts along the line joining the centres of the two masses. (Unit 3)

NEWTON'S SECOND LAW OF MOTION This states that a net force of magnitude F causes a body of mass m to accelerate in the direction of the net force with an acceleration of magnitude a according to the equation $F = ma$. (Unit 3)

NEWTON'S THIRD LAW OF MOTION This states that when two bodies interact, the force exerted by the first on the second is equal in magnitude and opposite in direction to the force exerted by the second on the first. (Unit 3)

NICHE A species' share of a habitat or the resources in it. The part of the habitat which a species can inhabit in the absence of competitors and predators is called its fundamental niche. The part it actually occupies, when competitors and predators are present, is called a realized niche. (Unit 25)

NITRIFICATION The process by which bacteria in soil or water convert ammonium ions into nitrate ions. (Unit 25)

NITROGENASE A complex enzyme, found in certain bacteria, involved in the reduction of nitrogen to ammonia. (Unit 22)

NITROGEN CYCLE The route taken by the element nitrogen in its cyclical movement between living and non-living parts of the natural world. The main part of

the cycle involves the movement between organic nitrogen compounds in organisms and inorganic nitrogen (nitrate or ammonium ions) in soil or water. (Unit 25)

NITROGEN FIXATION The process by which nitrogen gas is reduced to ammonia. Nitrogen fixation is carried out by certain bacteria and is the main way in which losses from the nitrogen cycle (by leaching and denitrification) are replaced. (Unit 25)

NOBLE GASES The gaseous chemical elements helium, neon, argon, krypton, xenon and radon, which are placed in a Group of the Periodic Table. They are so-named because of their marked reluctance to 'lower' themselves by combining with other chemical elements to form compounds. (Units 13–14)

NON-BONDING ELECTRON PAIRS When atoms of the non-metallic elements in Groups V–VII of the Periodic Table are covalently bonded in molecules, they do not need to share all their valence electrons to complete an outer octet of electrons. These unshared electrons (which are always in pairs) are called non-bonding electron pairs. (Units 17–18)

NON-CODING DNA DNA that does not carry a code for functional RNA molecules. Estimates suggest that only 20% of DNA has a coding function for RNA—the other 80% is non-coding DNA. In eukaryotes, some non-coding DNA is found in introns *within* split genes and much is found *between* genes. (Unit 24)

NON-DIPOLE COMPONENT OF THE EARTH'S MAGNETIC FIELD The (irregular and varying) part of the Earth's magnetic field that represents the difference between the observed field and the best-fitting dipole field. (Units 5–6)

NON-ELECTROLYTE A substance that dissolves in a liquid but does not increase the ability of the liquid to conduct electricity. (Units 13–14)

NON-METAL A term usually reserved for those chemical elements that are very poor electrical conductors in the solid and liquid states. (Units 13–14)

NON-OVERLAPPING CODE The codons in an mRNA molecule are 'read' in discrete units of three bases, and thus the codons do not overlap. (This is true of virtually all organisms—though there are some viruses where functional overlapping codes are found.) (Unit 24)

NON-POLAR SOLVENT A solvent (such as a hydrocarbon) that consists of molecules in which there is relatively little charge separation. Many molecular covalent substances dissolve readily in such solvents, but very few ionic substances do so. (Units 13–14)

NORMAL An imaginary line perpendicular to a boundary between two media. (Units 5–6)

NORMAL FAULT A steeply inclined fault caused by tension, in which rocks on the upper side of the fracture

drop down relative to rocks on the lower side due to the pulling apart of the rocks on either side of the plane. (Unit 27)

NORMAL OXIDE An oxide of the conventional kind in which every oxygen atom is bound, in its immediate vicinity, to other types of atom. This excludes peroxides and superoxides, which contain oxygen atoms bound to each other. (Units 13–14)

NORTH POLE OF A MAGNET The end of a bar magnet that is attracted towards the Earth's magnetic pole in the Northern Hemisphere. (Units 5–6)

N-TERMINAL AMINO ACID Term frequently used interchangeably with N-terminal residue. (Unit 24)

N-TERMINAL RESIDUE In peptides, polypeptides and proteins the amino groups and carboxyl groups of the constituent amino acids are condensed together as peptide bonds, except at each end. At one end there is a free amino group and at the other a free carboxyl group. The two amino acid residues involved are called, respectively, the N-terminal residue and C-terminal residue. The N-terminal residue, conventionally drawn at the left-hand end of the chain, has a free —NH_2 group. (Unit 22)

NUCLEAR BINDING ENERGY GRAPH Graph of the binding energy per constituent proton and neutron of nuclei plotted against mass number. (Unit 31)

NUCLEAR CHAIN REACTION A sequence of nuclear fission reactions initiated by a single nuclear fission reaction. (Unit 31)

NUCLEAR DECAY CHAIN A sequence of radioactive decays of nuclei. (Unit 31)

NUCLEAR DECAY CHANNEL One of the ways in which a nucleus can undergo radioactive decay. Some nuclei have more than one possible decay channel, e.g. the $^{214}_{83}\text{Bi}$ nucleus can undergo either β^- -decay, $^{214}_{83}\text{Bi} \rightarrow ^{214}_{84}\text{Po} + e^- + \bar{\nu}_e$, or α -decay, $^{214}_{83}\text{Bi} \rightarrow ^{210}_{81}\text{Tl} + ^4_2\text{He}$. (Unit 31)

NUCLEAR ENERGY The form of energy that is converted in a nuclear reaction. (Unit 9)

NUCLEAR FISSION The splitting of an atomic nucleus. The nucleus that splits almost always has a large mass number and it usually splits into two smaller nuclei and a number of particles such as neutrons. (Units 11–12 and 31)

NUCLEAR FUSION The combining of two atomic nuclei into one or more nuclei (and possibly other particles). (Units 11–12 and 31)

NUCLEAR REACTION A process in which atomic nuclei are converted into different nuclei. (Units 11–12)

NUCLEAR TRANSFER EXPERIMENTS Experiments that involve the transfer of a nucleus from one cell into another. For example, using the toad *Xenopus*, the scientist Gurdon transferred a nucleus from a differentiated cell (from the lining of its gut) into a fertilized egg, the nucleus of which had been previously destroyed. (Unit 24)

NUCLEIC ACID There are two types of nucleic acid: DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). DNA and RNA are condensation polymers in which the monomer is called a nucleotide. DNA and some types of RNA are chemicals that carry the genetic information of cells. (Units 17–18)

NUCLEOTIDES Monomers that, condensed together, form a nucleic acid. Each monomer consists of a phosphate group and a base attached to a ribose or deoxyribose molecule. (Units 17–18)

Nucleotides from DNA are properly termed deoxyribonucleotides, and those from RNA are called ribonucleotides. However, 'nucleotide' is sometimes used in a loose sense to mean either deoxyribonucleotide or ribonucleotide. (Unit 24)

NUCLEUS (chemistry and physics) The core of an atom, which contains nearly all of the atomic mass and is positively charged. With the exception of the hydrogen nucleus, which is a proton, nuclei consist of protons and neutrons. (Units 11–12)

The protons and neutrons in a nucleus are bound together by the strong interaction. (Unit 31)

NUCLEUS (biology) An organelle within a eukaryotic cell, containing the chromosomes. (Unit 19)

O

OBDUCTION The process by which oceanic crust is thrust upwards onto less dense continental crust at destructive plate margins, instead of being subducted beneath the continent. (Units 7–8)

OCEANIC CRUST The part of the Earth's crust that floors the ocean basins; it varies between 6 and 11 km thick and has an average composition close to that of basalt. (Units 5–6)

OCEAN RIDGE The elongated 'mountainous' part of the ocean floor that marks the zone at which sea-floor spreading takes place. (Units 7–8)

OCEAN TRENCH An elongated trough in the ocean floor, with a depth ranging from that of the abyssal plains to the greatest depths of the oceans (just over 11 km), that marks the zone at which subduction takes place. (Units 7–8)

OLIVINE A high temperature silicate rich in iron and magnesium, which can vary in composition ($(\text{Mg}, \text{Fe})_2\text{SiO}_4$) and has a structure with no cleavage. It is usually pale green-yellow in colour. It is the main

component of peridotite and can also be found in basalts. (Unit 27)

ONE-DIMENSIONAL MOTION Motion of a particle whose position (at each point along its path) can be completely specified by a single position component (e.g. x). (Unit 30)

OOZE The remains of calcareous or siliceous microfossils, individually too small to be seen by the naked eye, which accumulate as a soft mud on the ocean floor. (Unit 27)

OPHIOLITE SEQUENCE A characteristic sequence of rocks, ranging from peridotite at the base, through gabbro to basalt, with sedimentary rocks at the top, thought to be oceanic crust pushed onto continental crust by obduction. (Units 7–8)

OPTICAL ACTIVITY The rotation of the plane of polarization of plane-polarized light, brought about by a compound consisting predominantly or wholly of chiral molecules with the same configuration (that is, with the same 'handedness'). (Units 17–18)

OPTICAL ISOMERS Two molecules are optical isomers if a model of one is a mirror image of a model of the other. (Units 17–18)

ORBITAL The orbital of an electron is the region of space in an atom that the electron occupies. Each orbital corresponds to a particular set of quantum numbers. (Units 11–12)

ORBITAL ACCELERATION The acceleration of an object in orbit around a point. If the orbit is circular, the acceleration will be directed radially inwards. (Unit 3)

ORBITAL CIRCULAR MOTION The motion of an object in a circular path about a point. (Unit 1)

ORDER (biology) Part of the taxonomic hierarchy. Several families are gathered into one order, and several orders form one class. (Unit 21)

ORDER OF MAGNITUDE An approximation to the value of a quantity which rounds the value up or down to the nearest integral power of ten. For example, if one quantity is roughly 10^3 times another, the former quantity is said to be three orders of magnitude greater than the latter. (Unit 2)

ORGAN A structure within the body of a living organism; an organ may contain many different types of tissue, and it carries out a specific function. Examples: heart, brain, kidneys. (Unit 19)

ORGANELLE The name given to any characteristic structure within a cell. Organelles are present in (and are characterizing features of) eukaryotes, but apart from ribosomes they are not found in prokaryotes. (Unit 19)

ORGANIC CHEMISTRY The study of the compounds of carbon. (Units 17–18)

OUTCROP An exposure of rock that is visible at the surface and that is not detached from the rock unit it represents. (Units 28–29)

OUTER CORE The outer, liquid part of the Earth's core, which forms a spherical shell from 2900 to 5155 km below the Earth's surface and which is thought to be composed of an iron-sulphur mixture in which iron is by far the more abundant component. (Units 5–6)

OVULE Small structures in plants that each contain an egg nucleus—the female gamete in plants. (Unit 20)

OVUM Egg (female gamete) in animals. (Unit 20)

OXALOACETIC ACID This C_4 intermediate of the tricarboxylic acid (TCA) cycle combines with the C_2 molecule acetyl CoA (produced by the link reaction) to give citric acid, a C_6 intermediate of the TCA cycle. (Unit 22)

OXIDATION A chemical reaction that involves the addition of oxygen atoms, the removal of hydrogen atoms or, at its most fundamental, the removal of electrons. Oxidation is the opposite of reduction. (Units 17–18)

OXIDATIVE PHOSPHORYLATION The production of ATP in the electron transport chain. The process is described as oxidative because it depends on oxygen to reoxidize $NADH_2$ and $FADH_2$ (via the electron transport chain). (Unit 22)

OXYGEN DEBT The requirement for oxygen following exercise. Lactate accumulated by anaerobic respiration of exercising muscles is oxidized back to pyruvate using oxygen (via the electron transport chain). (Unit 22)

OXYGEN ELECTRODE A piece of apparatus (containing a platinum electrode) that measures the concentration of dissolved oxygen. (Unit 22)

OZONE LAYER The region of the stratosphere lying roughly between 15 and 40 km above the Earth's surface. It contains most of the atmospheric ozone, O_3 ; this shields the Earth's surface from most of that part of the Sun's ultraviolet radiation that is harmful to life. (Units 17–18 and 28–29)

P

PAIRING OF ELECTRONS The occupation of an orbital by two electrons that have opposite spins. (Units 11–12)

PALAEOECOLOGY The study, from their fossil remains, of how organisms interacted with each other and with their environments in the past. (Units 28–29)

PALAEOMAGNETIC POLES The positions of the geomagnetic poles in the geological past, determined

from magnetic inclinations recorded in rocks of known age. (Units 5–6)

PALAEOMAGNETISM The magnetization recorded in ancient rocks at the time of their formation. (Units 5–6)

PALAEONTOLOGY The scientific study of biological events in the past. (Unit 19)

PALMITIC ACID A long chain fatty acid (C_{16}) produced from fats by hydrolysis. (Unit 22)

PANCREAS A gland in vertebrates lying near the liver. Among its functions is the secretion of insulin into the blood. (Unit 23)

PARASITOID An insect parasite that lays its eggs inside the eggs, larvae or pupae of another insect, where the parasitoid larva feeds and develops, finally killing its host. (Unit 25)

PARASYMPATHETIC NERVOUS SYSTEM In vertebrates, the parasympathetic nervous system is part of the nervous system that is not under voluntary control. It carries motor (movement) instructions from the brain. Where it interacts with the sympathetic system (e.g. in the heart) it often acts antagonistically. (Unit 23)

PARENTAL GENERATION, P Parents (usually pure-breeding) that produce F_1 offspring. (Unit 20)

PARENT ISOTOPE An isotope that decays radioactively to form a daughter isotope. (Units 28–29)

PARTIAL MELTING The processes by which the minerals with the lowest melting points in a rock are the first to melt. The resulting magma can move away from the site of melting and ultimately crystallize as new rocks with a composition different from that of the parent. The partial melting of mantle peridotite results in basaltic magmas. The partial melting of andesitic rocks can produce rocks of a granitic composition. (Unit 27)

PARTICLE PHYSICS The branch of physics that is concerned with fundamental particles and their interactions. Also called high-energy physics. (Unit 32)

PASSIVE CONTINENTAL MARGIN A boundary between oceanic and continental crust that is neither the site, nor the result, of ocean/continental collision. This type of margin lies within a lithospheric plate. (Unit 7–8)

PEPSIN A digestive enzyme, produced in the stomach, that hydrolyses protein. Pepsin has a pH optimum of around 2. (Unit 22)

PEPTIDE BOND The amide link, $\text{—}\overset{\text{O}}{\underset{\text{O}}{\text{C}}}\text{—NH—}$, between amino acid residues in peptides or proteins. (Units 17–18)

PERIDOTITE A dense, coarse-grained, crystalline rock characteristic of the lowest oceanic crust and which is the principal rock type forming the Earth's mantle. (Units 5–6)

Peridotite is composed largely of olivine with some pyroxene. (Unit 27)

PERIOD (physics) The time taken to complete one sequence in a periodic process. (Unit 1)

PERIOD (chemistry) A series of chemical elements, commonly placed in a horizontal row in a Periodic Table. Across the row, atomic number increases in steps of one, and there is a variation in chemical properties that is repeated within other corresponding series of the Periodic Table. (Units 13–14)

PERIOD (Earth sciences) A unit of geological time based on fossil characteristics in sedimentary rocks (a subdivision of Era). (Units 28–29)

PERIODIC LAW (chemistry) A proposition first made by Mendelëev; the modern version states that the chemical elements, when placed in order of atomic number, display an evident periodicity of properties. (Units 13–14)

PERIODIC PROCESS (physics) A process in which an event is repeated at regular intervals. (Unit 1)

PERIODIC TABLE An arrangement of the chemical elements in space, that tries to give expression to the Periodic Law. (Units 13–14)

PERIOD OF A WAVE The time T required for a wave to move forward by one wavelength λ . If a wave has constant speed v , then $T = \lambda/v$. (Unit 10)

PHASE Two waves are said to be in phase when their troughs coincide and their crests coincide. They are said to be completely out of phase when the troughs of one wave coincide with the crests of the other wave, and vice versa. (Unit 10)

PHASE CHANGE A change in the internal structure of a substance, which usually results in the substance having distinctly different physical properties although the chemical composition remains the same. A typical example is the melting of a solid into a liquid. (Units 5–6 and 16)

PHASE OF A SUBSTANCE The form (gas, liquid or solid) in which a substance occurs. It is denoted in the chemical formula of the substance by the letter g, l or s in brackets. For example, liquid water is denoted by $\text{H}_2\text{O}(\text{l})$. (Units 13–14)

PHENOTYPE The sum of all the characters that an organism possesses. The term may also be used to refer to a specific character, e.g. the 'purple-grain phenotype of maize'. (Unit 19)

PHENYL GROUP A hydrocarbon group of formula C_6H_5- with the same shape and arrangement of

double bonds as benzene but having one fewer hydrogen atoms (sometimes abbreviated to Ph—). (Units 17–18)

PHEROMONE A chemical compound (or mixture of compounds) released in minute amounts that acts as a specific signal by which insects and other animals communicate with others of the same species. (Units 17–18)

pH See pH scale.

pH OPTIMUM The particular pH at which a given enzyme is most active. (Unit 22)

PHOSPHOLIPID A class of fatty substances, containing phosphate groups. Phospholipids are important constituents of cell membranes. (Unit 22)

PHOTOELECTRIC EFFECT The process in which an electron is ejected from a solid by a photon. In this process the electron completely absorbs the energy of a single photon. (Units 10 and 30)

PHOTOELECTRON An electron that has been ejected from a solid by a photon. (Unit 10)

PHOTOELECTRON SPECTROSCOPY A type of spectroscopy that examines the energies of the photoelectrons produced by bombarding an atom with radiation of a fixed frequency, and so gives a measure of the ionization energies of the electrons in the atom. (Units 11–12)

PHOTON A particle of electromagnetic radiation. The energy E of a photon is given by the equation $E = hf$, where f is the frequency of the radiation, and h is Planck's constant. The momentum of a photon has magnitude $p = E/c$ (where c is the speed of light in a vacuum) and its direction is the same as the photon's direction of motion. (Units 10 and 30)

The photon is the gauge boson that mediates electromagnetic interactions. (Unit 32)

PHOTOPHOSPHORYLATION The process by which ATP is made from ADP and P_i in the light stage of photosynthesis. (Unit 22)

PHOTOSYNTHESIS The synthesis, by green plants and some bacteria, of organic compounds using the energy of sunlight. Carbon dioxide is reduced to carbohydrate by hydrogen atoms derived (in all photosynthetic organisms except certain bacteria) from water. Oxygen is produced as a consequence. (Unit 22)

pH SCALE A scale that provides a convenient measure of the acidity of an aqueous solution. The pH of a solution is calculated from the definition:

$$\text{pH} = -\log \left\{ \frac{[\text{H}^+(\text{aq})]}{\text{mol l}^{-1}} \right\}$$

The lower the pH, the more acid the solution. (Unit 15)

PHYLLITE A fine-grained metamorphic rock, composed of re-crystallized clay minerals, formed at higher temperatures and pressures than slate but lower temperatures and pressures than schist. It often has a finely wrinkled surface owing to slight folding of pre-existing cleavage. (Unit 27)

PHYLUM Part of the taxonomic hierarchy. Several classes are gathered into one phylum and several phyla form one kingdom. (Unit 21)

PHYSICAL WEATHERING The breakdown of rocks *in situ*, by physical processes such as frost shattering, and abrasion. (Unit 27)

PHYSICO-CHEMICAL FACTORS The non-living factors (e.g. pH, temperature, wetness) that influence an environment (cf. biotic factors). (Unit 25)

PHYSICS The branch of science concerned with the behaviour of matter and energy. (Unit 3)

PHYSIOLOGY The branch of biology concerned with the interrelationships of organs and organ systems, and of the organism with its external environment. (Unit 22)

There are several subdivisions, such as animal physiology, plant physiology, microbial physiology, comparative physiology etc. (Unit 23)

PHYTOPLANKTON Plankton composed of plants (the Greek word *phyto* means plant). Plankton is the collective term for water-borne microscopic organisms, and includes phytoplankton and zooplankton. (Unit 25)

π The ratio of the circumference of a circle to its diameter. To four significant figures, $\pi = 3.142$. (Unit 2)

P_i See inorganic phosphate. (Unit 22)

PILLOW LAVAS Basaltic lavas extruded under water; so called because of their pillow-like shape in cross-section. (Units 5–6)

PLAGIOCLASE A member of the feldspar group of minerals with composition between $\text{CaAl}_2\text{Si}_2\text{O}_8$ and $\text{NaAlSi}_3\text{O}_8$. (Unit 27)

PLANCK'S CONSTANT, h A universal constant whose value is approximately $6.626 \times 10^{-34} \text{ J s}$. (Unit 10)

PLANE-POLARIZED LIGHT Light in which the electric (or magnetic) field oscillations take place in a single plane. (Units 17–18)

PLANET Any celestial body that orbits the Sun or another star. In the Solar System, the nine planets orbiting the Sun are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. (Unit 1)

PLANE WAVE A wave whose wavefronts are parallel planes that are each perpendicular to the direction of motion of the wave. (Unit 10)

PLANKTON See phytoplankton and zooplankton.

PLANT RESPIRATION, R The amount of energy released (as heat) when plants respire (usually expressed in $\text{kJ m}^{-2} \text{ yr}^{-1}$). R is related to GPP and NPP by the equation $NPP = GPP - R$. (Unit 25)

PLASMA (biology) An aqueous solution of inorganic salts that carries the blood cells in the circulatory system. It also contains proteins, hormones and nutrients. (Unit 23)

PLASMIDS Small circular DNA molecules found in bacteria. They replicate separately from the DNA of the bacterial chromosome. (Unit 24)

PLASTIC DEFORMATION OF ROCKS At high temperatures, rocks stretch and become thinner when under tension, and under compression they tend to bulge rather than rupture. This behaviour is known as plastic deformation and contrasts with brittle deformation. (Unit 27)

PLASTICIZER A substance, generally a low molecular mass ester, which when added to an otherwise rigid polymeric material renders it flexible. (Units 17–18)

PLATELETS Small blood cells without nuclei that assist in wound healing. They plug small holes that continuously appear in the walls of capillaries, and they promote blood clotting in wounds. (Unit 23)

PLATE TECTONIC THEORY A theory that states that the outer 100 km of the Earth consists of rigid slabs, called plates, which are in motion relative to each other and to the interior of the Earth. (Units 7–8)

PLUTON The general name for any large-scale mass of intrusive (plutonic) igneous rock. (Unit 27)

PLUTONIC ROCKS Igneous rocks that are intrusive. (Pluto was the Greek god of the Underworld.) (Units 5–6 and 27)

POLAR FRONT The boundary between the cold air mass associated with either Pole and the warmer air from lower latitudes. (Units 28–29)

POLARIS The star that, in the Northern Hemisphere, does not appear to be moving across the sky. Polaris is always directly overhead at the geographic North Pole. (Unit 1)

POLAR SOLVENT A solvent composed of molecules within which there is substantial charge separation. Ionic substances often dissolve readily in such solvents. (Units 13–14)

POLLEN Microscopic structures produced in vast numbers by plants. Each can give rise to a sperm cell the male gamete in plants. (Unit 20)

POLYAMIDE A condensation polymer in which the constituent units are linked through amide groups. (Units 17–18)

POLYATOMIC ION Two or more atoms bound together, and carrying an integral number of positive or negative charges; the sulphate ion, SO_4^{2-} , is an example. (Units 13–14)

POLYDEOXYRIBONUCLEOTIDES The full name of DNA molecules—polymers of deoxyribonucleotides. (Unit 24)

POLYESTER A condensation polymer in which the constituent units are linked through ester groups. (Units 17–18)

POLYMER A large molecule formed by the linking together of many smaller molecules known as monomers. (Units 17–18)

POLYMERIZATION The sequence of reactions involved in the formation of a polymer. (Units 17–18)

POLYMORPHISM The situation in which there are at least two distinct phenotypes or genotypes in a population. Unless the polymorphism is balanced, the frequency of one genotype and its associated phenotype will increase at the expense of the other. (Unit 21)

POLYNUCLEOTIDE A condensation polymer in which the monomer is a nucleotide. There are two types found in living organisms, DNA and RNA. (Units 17–18)

POLYPEPTIDE A heteropolymer formed from a selection of the 20 or so naturally occurring amino acids. (Units 17–18)

The term polypeptide is used instead of protein (a) when referring to a newly synthesized linear chain or (b) when referring to one of the component chains of a protein containing two or more polypeptide chains per molecule, e.g. haemoglobin. Sometimes 'polypeptide' is used interchangeably with 'protein'. (Unit 22)

POLYRIBONUCLEOTIDES The full name of RNA molecules—polymers of ribonucleotides. (Unit 24)

POLYSACCHARIDE A condensation polymer in which the monomer is a monosaccharide. Saccharides are molecules containing the elements carbon, hydrogen and oxygen with a large number of hydroxyl groups in addition to a carbonyl group. The monomers have molecular formulae $(\text{CH}_2\text{O})_n$, where n is most commonly 5 or 6. Saccharides are also known collectively as carbohydrates. (Units 17–18)

POLYSOME (POLYRIBOSOME) The name for a structure in which a number of ribosomes and partially made polypeptides are associated with one mRNA molecule. Polysomes can sometimes be seen in electron micrographs of cells. (Unit 24)

PONS Region of the mammalian brain involved in the control of respiration. It is responsible for inhibiting inspiration and thus initiates expiration. (Unit 23)

POPULATION A group of organisms of the same species, living in the same area and capable of interbreeding. (Units 19 and 25)

POPULATION DENSITY The number of individuals in a given population per unit area. (Unit 25)

POSITION ISOMERS Two molecules are position isomers if they are structural isomers that have the same carbon skeleton, and the same functional group. An example of such a pair is propan-1-ol, $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—OH}$, and propan-2-ol, $\text{CH}_3\text{—CH—CH}_3$ (Units 17–18)

$$\begin{array}{c} | \\ \text{OH} \end{array}$$

POSITIVE FEEDBACK The process by which a system reacts to a change within itself by increasing the change. This is an unstable state, which is uncommon in nature. (Unit 23)

POST-TRANSCRIPTIONAL MODIFICATION Modification of mRNA after transcription, by the removal of non-coding sequences. An example is the removal of introns. (Unit 24)

POST-TRANSLATIONAL MODIFICATION Modification of newly produced polypeptide chain(s) to give a functional protein. So named because modification occurs immediately after translation. An example is the removal of N-terminal methionine. (Unit 24)

POTENTIAL DIFFERENCE See voltage difference. (Unit 9)

POWER The rate of transfer of energy. The SI unit of power is the watt, W: $1 \text{ W} = 1 \text{ J s}^{-1}$. (Unit 9)

POWERS-OF-TEN NOTATION A notation in which a number is written as the product of an integral power of ten and a number (normally between 0 and 10). For example, in powers-of-ten notation, 73 874 is written as 7.3874×10^4 . Also known as scientific notation. (Unit 2)

PRECIPITATE A sparingly soluble solid that appears in what was previously a clear solution because of a chemical reaction. (Unit 15)

PRECISE MEASUREMENT A measurement in which the random uncertainties are minimal (cf. accurate measurement). (Unit 4)

PRECURSOR A molecule from which another molecule is formed: e.g. amino acids are the precursors of proteins. (Unit 22)

PRESSURE The perpendicular force per unit area (pressure = perpendicular force/area). The SI unit of pressure is N m^{-2} . (Units 5–6)

PRIMARY ALCOHOL An alcohol in which the hydroxyl group is attached to a carbon atom that itself is attached to one other carbon atom and two hydrogen atoms; for example butan-1-ol, $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—OH}$. (Units 17–18)

PRIMARY PRODUCER A term applied to all autotrophs, indicating that they produce carbohydrate by photosynthesis—so converting solar energy (the primary source of energy) into stored chemical energy. (Unit 25)

PRIMARY STRUCTURE The sequence of amino acids in a protein or polypeptide. That sequence determines the higher-order structure. (Unit 22)

PRINCIPAL QUANTUM NUMBER, n The quantum number used to label the electron energy levels in atoms according to shells that contain the electrons; n may have the values 1, 2, 3 ... etc. (Units 11–12)

PRINCIPLE OF FAUNAL SUCCESSION The principle that there is a recognizable succession of fossils for each period of geological history, and this sequence is the same wherever the rocks of that period occur. (Units 28–29)

PRINCIPLE OF SUPERPOSITION (physics) Waves are able to 'pass through' each other without hindrance, and without having an effect on each other's future behaviour. At the point of crossing, though, the waves are said to superpose. The principle of superposition states that the resultant disturbance at any point is the sum of all the contributing disturbances at the same point. (Unit 10)

PRINCIPLE OF SUPERPOSITION (Earth sciences) The principle that younger rocks are deposited on top of older rocks and hence overlie them in a stratigraphic sequence. (Units 28–29)

PRINCIPLE OF UNIFORMITARIANISM The principle that geological processes operating at present also operated in the past. (Units 28–29)

PRODUCER See autotroph.

PRODUCT (chemistry) A substance that is produced during a chemical reaction. (Units 13–14)

PRODUCTION ECOLOGY The study of the flow of energy within and between trophic levels in ecosystems. (Unit 25)

PROKARYOTE A single-celled organism with no distinct nucleus. (Units 19 and 28–29)

PROPHASE See meiosis and mitosis

PROPORTIONALITY Two quantities are said to be proportional to each other if a change by a factor in one of them implies a change by the same factor in the other. If the quantity y is proportional to x , their relationship is written as $y \propto x$. (Unit 2)

PROSTHETIC GROUP A non-protein component of some biologically active proteins. The haem of haemoglobin is an example of a prosthetic group. (Unit 22)

PROTEIN A very large, naturally occurring polyamide formed from a selection of the 20 or so naturally occurring amino acids. (Units 17–18)

Thus, a protein molecule is a polymer of amino acids and consists of one or more polypeptide chains; for example, myoglobin has one chain, insulin two chains and haemoglobin four chains. Protein structure is determined by structural genes. (Unit 22)

PROTEIN HALF-LIFE The time it takes for half the protein (of a given kind or in a given location) to be replaced. Protein half-life varies from tissue to tissue. It can be measured by isotopic labelling (using ^{14}C amino acids). (Unit 22)

PROTON The nucleus of the hydrogen atom and a constituent of all other nuclei. The particle has a relative mass very close to one on the relative atomic mass scale, and is positively charged (the charge is usually denoted by +1). (Units 11–12)

PULMONARY CIRCULATION The route taken by blood from the right ventricle of the heart to the lungs via the pulmonary artery, and back to the left atrium of the heart via the pulmonary vein. Together with the systemic circulation, it makes up the double circulation. (Unit 23)

PUMICE A pale-coloured vesicular volcanic rock, formed by the explosive eruption of silica-rich magma. (Units 5–6)

PUPA An insect in the stage between larva and adult. (Unit 25)

PURE-BREEDING A term applied to members of a strain of animals or plants that possess a particular phenotypic character and which, when interbred over successive generations, produce offspring all of which also possess that character. (Unit 20)

PURINE BASE (purine ring) The two-ring structure of nitrogen and carbon atoms, as seen in the bases adenine and guanine. (Unit 24)

P-WAVES Compression waves (or 'push-pull waves') caused by a disturbance consisting of a pressure pulse. They were originally named P-waves because they are the first or primary waves to arrive from an earthquake. (Unit 5–6)

P WAVE SHADOW ZONE The zone of the Earth at epicentral angles between 103° and 142° from an earthquake epicentre, within which there are no P-wave arrivals from the earthquake. (Units 5–6)

PYRIMIDINE BASE (pyrimidine ring) The single-ring structure of nitrogen and carbon atoms, as seen in the bases cytosine, thymine and uracil. (Unit 24)

PYRITE An iron-sulphur mineral with composition FeS_2 . (Units 28–29)

PYROCLASTIC ROCKS Literally 'fire-broken rocks'. Rocks formed from the fragmentation of explosively ejected lava which, after being flung into the air, is deposited as ash and cinders (see also pumice). (Unit 27)

PYROXENE A group of silicate minerals rich in iron and magnesium with variable composition, $\text{Ca}(\text{Mg,Fe})\text{Si}_2\text{O}_6$ and $(\text{Mg,Fe})_2\text{Si}_2\text{O}_6$. The silicate tetrahedra are in chain structures, giving the mineral cleavage in two directions. Pyroxenes are usually dark green or black in colour, and are mainly found in iron-rich igneous rocks, e.g. gabbro. (Unit 27)

PYRUVATE DECARBOXYLASE An enzyme that catalyses the conversion of pyruvic acid into carbon dioxide and acetaldehyde. The latter is then reduced to ethanol. These reactions occur during anaerobic respiration in yeast. (Unit 22)

PYRUVIC ACID An important metabolite produced by glycolysis in the cytosol. Under aerobic conditions it passes to the mitochondria, where the link reaction converts it into acetyl CoA. In anaerobic conditions it is reduced (in the cytosol) to lactic acid. At cellular pH it exists as pyruvate ions; the terms 'pyruvic acid' and 'pyruvate' are often used interchangeably by biochemists. (Unit 22)

PYTHAGORAS'S THEOREM In a right-angled triangle, the sum of the squares of the lengths of the sides forming the right angle is equal to the square of the length of the hypotenuse (the side opposite the right angle). (Unit 3)

Q

QUANTIZATION The restriction of a variable to certain definite (quantized) values. For example, the energy of electromagnetic radiation with frequency f is quantized: each quantum has energy $E = hf$, where h is Planck's constant. (Units 10 and 31)

QUANTIZATION OF ENERGY A term used to describe the restriction of the energy of particles to particular values. Electrons in atoms have quantized energies. (Units 11–12)

QUANTUM A term that can be applied to matter and to electromagnetic radiation in order to avoid referring to either as 'particles' or as 'waves'. These latter terms can be used only in certain circumstances ('particles' for interactions, 'waves' for propagation), whereas the term 'quantum' refers to both types of behaviour. Hence, by using the term 'quantum', the need to specify whether interactions or propagation are being described can be conveniently avoided. It is, however, conventional (if somewhat lax) to refer to quanta of matter as particles. (Unit 30)

QUANTUM CHROMODYNAMICS The theory that is currently regarded as the best available theory of the strong interactions between quarks. (Unit 32)

QUANTUM ELECTRODYNAMICS A theory that can describe both the wave and particle behaviour of electromagnetic radiation. (Unit 10)

QUANTUM MECHANICS A theory that can describe the propagation of matter and its interactions with other matter. (Unit 30)

QUANTUM NUMBER A quantity whose possible values characterize the possible wavefunctions of a particle. In the case of a particle confined in one dimension between parallel plates, only one quantum number n (which can have the value 1 or 2 or 3 etc.) is required to specify each of the particle's possible wavefunctions. However, for a particle that is confined in three dimensions in a cube, *three* quantum numbers (n_1, n_2, n_3) are required (n_1, n_2 and n_3 can each be equal to 1 or 2 or 3 etc.). (Unit 31)

QUARK A type of particle, currently believed to be fundamental, that is a constituent of hadrons. There are known to exist several varieties of quark, although none has ever been observed in isolation. According to quantum chromodynamics, such an observation will never be made. (Unit 32)

QUARTZ A common rock-forming mineral composed of silica. It occurs in sedimentary, igneous and metamorphic rocks: for example, it is found as grains cemented together in sandstones, and (together with feldspar and mica) in granites. (Units 5–6)

Quartz has a three-dimensional framework structure of silicate tetrahedra with no regular planes of weakness (i.e. no cleavage). The mineral has a hardness greater than steel and is resistant to chemical weathering. (Unit 27)

R

RACE See subspecies. (Unit 21)

RACEMIC MIXTURE A 1 : 1 mixture of two optical isomers of a compound. (Units 17–18)

RADIAN A dimensionless unit of angular measure, defined such that, for any circle, the arc subtended by an angle of 1 radian has a length equal to that of the circle's radius. 1 radian $\approx 57.3^\circ$. (Unit 2)

RADICAL A reactive molecule or molecular group with an atom that has one fewer electrons than needed to complete its outer octet. (Units 17–18)

RADIOACTIVE DECAY The spontaneous decay of an atomic nucleus (usually of one of the heavier elements) into a lighter nucleus, for example by the emission of α - or β -particles or γ -radiation. (Units 11–12 and 31)

RADIOACTIVITY The emission of particles from atomic nuclei in radioactive decays. (Units 11–12)

RANDOM UNCERTAINTY The kind of uncertainty in a reading that arises from random operator error or from limitations in the scale on which the reading is based. Random uncertainties can be reduced by averaging repeated measurements. (Unit 3)

RARE EARTH ELEMENTS A set of chemical elements that resemble each other very closely. They include the lanthanides (elements 57–70 as defined in this Course) and lutetium (element 71). (Units 13–14)

RAREFACTION PULSE The stretching of a material behind a compression pulse (also called dilatation). (Units 5–6)

REACTANT A substance that takes part in a chemical reaction and whose constituent atoms appear in the products of the reaction. (Units 13–14)

REACTION-COORDINATE DIAGRAM A diagram that shows how the total energy of the chemicals involved in a chemical reaction varies as the reactants progressively change into the products. (Unit 16)

REACTION MECHANISM The progressive changes that take place at the molecular level as the reactants in a chemical reaction are converted into the products. (Unit 16)

REALIZED NICHE See niche. (Unit 25)

RECEPTOR Part of an animal or plant that detects what goes on inside or outside the organism. (Unit 23)

RECESSIVE CHARACTER If an animal or plant is heterozygous at a particular locus, and if the phenotypic character of only one of the alleles at that locus is shown, then the character that is *not* shown is said to be recessive. (The one that is shown is said to be dominant.) The allele responsible for the recessive character is also termed the recessive allele. (Unit 20)

RECOMBINATION The production of new combinations of alleles during gamete production by meiosis. Recombination usually involves both crossing over and independent assortment. (Units 20)

REDBEDS Sedimentary rocks formed in an oxidizing environment. All the iron in the rock is present as iron(III). (Unit 28–29)

RED CELLS The red cells in the blood contain haemoglobin, which is a transport molecule for oxygen. The cells are biconcave discs, with no nuclei. (Units 19, 21 and 23)

REDUCTION A chemical reaction that involves the addition of hydrogen atoms, the removal of oxygen atoms or, at its most fundamental, the addition of electrons. Reduction is the opposite of oxidation. (Units 17–18)

REFERENCE LEVEL (biology) The output or level that a homeostatic regulation system maintains. (Unit 23)

REFLECTION OF A WAVE The 'bouncing' of a wave off a surface in such a way that the wave direction is changed according to the rule that the angle of incidence is equal to the angle of reflection. (Both these angles are measured relative to the normal—i.e. the direction at right angles—to the reflecting surface at the point at which the wave is incident.) (Unit 10)

REFLECTION PROFILE (Earth sciences) A cross-sectional plot (horizontal distance against depth) of seismic reflections showing a pattern (in the form of dark and light bands) from which a picture of the strata lying within the section can be deduced. (Units 5–6)

REFRACTION OF A WAVE The process in which a wave's direction of propagation is changed as it travels across a boundary. The bending is a direct consequence of the different speeds of the wave in the two materials. (Unit 10)

REGIONAL METAMORPHISM The metamorphism of large volumes of crustal rocks. It is characterized by the growth of new minerals and by a change in texture (often an alignment of platy minerals) in the rock. (Unit 27)

REGULATING MORTALITY FACTOR A mortality factor whose pattern of annual k -value variation is the converse of the pattern of annual k_{total} (the total generation pre-reproductive mortality) variation. The regulating mortality factor is always dependent on the population density. Its effect is to alter the population density towards an average level and so reduce fluctuations. (Unit 25)

REGULATORY ENZYME Every metabolic pathway has at least one enzyme whose activity changes according to the biochemical needs of the cell. It becomes more active or less active depending whether more or less product is required. Such enzymes are called regulatory enzymes. (Unit 22)

RELATIVE ABUNDANCES The relative amounts of the various isotopes of an element that occur naturally. (Units 11–12)

RELATIVE ATOMIC MASS, A_r A measure of atomic mass, defined on a scale in which the ^{12}C isotope of carbon has a value of exactly 12. It is the mass of an atom divided by one-twelfth of the mass of an atom of ^{12}C . It is expressed as a number, without a unit. (Units 11–12 and 13–14)

RELATIVE DATING METHOD A method of determining the sequence of geological events, usually by means of the principle of faunal succession. (Units 28–29)

RELATIVE MOLECULAR MASS The ratio of the mass of one molecule of a compound to one-twelfth of

the mass of one atom of ^{12}C . It has the same numerical value as the molar mass of the compound. (Units 17–18)

RELIEF (Earth sciences) The variation in height of the surface of the Earth, for example mountains, valleys, and ocean ridges and trenches. (Units 5–6)

REMOTE SENSING Collecting and interpreting information about a target without being in contact with it. The target is usually the surface of the Earth, in which case the information is typically a photograph or an electronically recorded image based on visible light, infrared radiation or radar techniques, acquired from an aircraft or spacecraft (such as a satellite). (Units 28–29)

REPLICATION (biology) The production of an exact copy of a component of an organism. (Unit 19)

REPRESENTATIONS OF A WAVE Because waves have a shape in space that changes with time as the wave moves forward, it is necessary to specify both how the wave varies with position, and how it varies with time. These two representations are complementary—both are needed to specify the wave completely. If only one of the graphs is specified, the information that would be contained in the other graph can only be calculated if the wave's speed is known, and if it can be assumed that the wave propagates in an unchanging way. (Unit 10)

REPRODUCTION The production by an organism of descendants. In sexual reproduction this involves a stage in the organism's life history called a gamete that is comparatively simple in structure. (Unit 19)

REPRODUCTIVE ISOLATION The situation in which groups of organisms do not interbreed and so their gene pools do not mix. It can be brought about by behavioural isolation or geographical isolation. (Unit 21)

RESIDUAL MINERALS Minerals that are left after a rock has been weathered. Residual minerals are of two types: (1) minerals produced by the breakdown of other minerals, for example, feldspar into clay minerals; (2) minerals that resist chemical attack, or are hardly affected by it, for example, quartz. (Unit 27)

RESPIRATION A loosely used term that normally refers to aerobic respiration in cells. In some contexts it can mean the processes involved in extracting oxygen from the environment e.g. breathing. (Unit 22)

REST MASS The mass of an entity as measured by an observer relative to whom the entity is at rest. (Unit 31)

RETROGRADE LOOP A path executed by a planet in which it appears temporarily to reverse its direction of movement across the sky, later resuming motion in its original direction. (Unit 1)

REVERSE FAULT A steeply inclined fault caused by compression, in which the upper side of the fault moves up relative to rocks on the lower side. In a reverse fault the angle between the fault plane and the horizontal is large. If this angle is small, the fault is called a thrust. (Unit 27)

R GROUP The majority of the naturally occurring amino acids have the general formula

$$\begin{array}{c} \text{R}-\text{CH}-\text{C}-\text{OH} \\ | \quad | \\ \text{NH}_2 \quad \text{O} \end{array}$$

resents a group of atoms, and is referred to as the R group. (Unit 22)

RHYOLITE A volcanic rock with a very fine-grained or glassy texture caused by the extrusion of magma with a granitic composition. Colour can be very variable and the rock often shows banding as the result of the materials being 'smeared out' by the flow of the lava. Rhyolitic lavas are rare because the magma is extremely viscous and tends either to solidify before eruption or to erupt explosively. (Units 5–6)

RIBONUCLEOTIDES The chemical units (monomers) that are polymerized to form RNA. Each has three parts: a sugar (ribose), a phosphate group, and a base. Since there are four different bases (adenine, guanine, cytosine and uracil), there are four different ribonucleotides. When the context permits they are simply referred to as nucleotides. (Unit 24)

RIBOSE A sugar molecule, containing five carbon atoms, involved in the structure of ribonucleotides—hence of RNA. (Unit 24)

RIBOSOMAL RNA, rRNA The RNA that, together with protein molecules, makes up the very small structures known as ribosomes. (Unit 24)

RIBOSOMES The sites of protein synthesis in the cell. Ribosomes are usually attached to the endoplasmic reticulum. (Unit 22)

When attached to mRNA molecules, these very small structures provide a protected environment that allows the weak bonding between tRNA molecules and the mRNA molecule to be maintained long enough for each incoming amino acid to be added to the growing polypeptide chain. (Unit 24)

RICHTER SCALE The logarithmic scale of earthquake magnitude devised by Charles Richter. (Units 5–6)

RIDGE-PUSH FORCE The gravitational force that acts on lithospheric plates resulting from the high relief of ocean ridges. (Units 7–8)

RIGIDITY MODULUS, μ The ratio that is a measure of the elastic behaviour of a rock when subject to shear. Specifically, μ is the ratio of shear stress to shear strain. The SI unit of rigidity modulus is N m^{-2} . (Units 5–6)

RNA (ribonucleic acid) A heteropolymer in which the monomer is a composite molecule consisting of a phosphate group joined to a ribose molecule, which in turn is joined to one of four different organic bases—adenine, cytosine, guanine and uracil. Molecules of RNA are much smaller than those of DNA, with relative molecular masses as low as 35 000. (Units 17–18)

The monomers of RNA are called ribonucleotides, thus the heteropolymer is a polynucleotide. Each RNA molecule consists of one such polymeric strand. RNA molecules are involved in the process of protein synthesis in the cell (see mRNA, tRNA and rRNA). (Unit 24)

ROCK Any mass of minerals whether consolidated or not. A rock may consist of one mineral species, but it more usually consists of an aggregate of minerals. Rocks can be classified as sedimentary, igneous or metamorphic. (Unit 27)

ROCK CYCLE The cycle in which rocks are continuously made and destroyed. Rocks exposed at the Earth's surface are subjected to processes of weathering and erosion; the particles formed are transported and deposited as sediments, which may then be compacted and subjected to high temperatures and pressures so that metamorphic rocks form. Ultimately, partial melting may occur and the magma may then erupt or be intruded. Intrusive rocks may eventually be exposed at the surface and be subjected to weathering and erosion. (Unit 27)

ROCK-STRATIGRAPHIC COLUMN The array of beds or rock units that results from stacking them vertically, with the oldest at the base overlain by successively younger beds. (Units 28–29)

rRNA See ribosomal RNA. (Unit 24)

RUTHERFORD ATOMIC MODEL A model of the atom, based on the results of an experiment in which α -particles are scattered by atomic nuclei. The atom is supposed to consist of a central, massive, positively charged nucleus surrounded by electrons. (Units 11–12)

S

SALT A substance formed by the conjunction of the cation of a base with the anion of an acid. Aqueous solutions of salts are formed in neutralization reactions. (Unit 15)

SANDSTONE A rock made of particles of sand (often quartz) that have been laid down in layers (strata) and subsequently buried, compacted and cemented together. (Units 5–6)

SATURATED COMPOUND Term used to describe an organic compound with molecules in which all the atoms are connected by single bonds. In particular, each carbon atom is joined to four other atoms. (Units 17–18)

SATURATED SOLUTION A solution at constant temperature that is made by dissolving as much solute as possible in a fixed amount of solvent at that temperature. (Unit 15)

SCHIST A coarse-grained metamorphic rock with a large proportion of platy minerals such as mica flakes, which are aligned in one direction. Fairly high temperatures (at least 400 °C) and pressures are required for its formation. (Unit 27)

SCHRÖDINGER EQUATION An equation that enables the possible wavefunctions (and the corresponding energy values) of a quantum of matter to be calculated. (Unit 30)

SCIENTIFIC NOTATION See powers-of-ten notation. (Unit 2)

SEA-FLOOR SPREADING The process by which the lithospheric plates on either side of a constructive plate margin (ocean ridge) grow at the ridge by the addition of igneous material of basaltic–gabbroic composition, as the plates on either side of the ridge spread apart. (Units 7–8)

SEAMOUNT An isolated tall volcano submerged on the deep ocean floor, often more or less conical in shape. Some seamounts have flat tops and are then known as guyots. (Units 7–8)

SECOND, s The SI unit of time. (Unit 2)

SECONDARY ALCOHOL An alcohol in which the hydroxyl group is attached to a carbon atom that itself is attached to two other carbon atoms and a hydrogen atom; for example, butan-2-ol, $\text{CH}_3\text{—CH}_2\text{—CH—CH}_3$. (Units 17–18)



SECOND FILIAL GENERATION, F_2 The offspring produced when F_1 offspring are crossed with each other. (Unit 20)

SECOND QUANTUM NUMBER, l The quantum number that characterizes the subshells of an atom; l may have values 0, 1, 2 ... ($n - 1$), where n is the principal quantum number. This quantum number is also called the orbital angular momentum quantum number. (Units 11–12)

SECULAR VARIATIONS OF THE EARTH'S MAGNETIC FIELD The changes with time of the Earth's magnetic field. These changes result from a dynamic magnetic field source within the Earth. (Units 5–6)

SEDIMENTARY ROCKS Rocks that are formed from sediments laid down at the Earth's surface, and that have subsequently undergone processes such as compaction and cementation. Sedimentary rocks usually have a fragmental texture, with individual grains cemented together. Sandstones, mudrocks and limestones are examples of sedimentary rocks. (Units 5–6)

SEISMIC DISCONTINUITY A distinct boundary separating two media of different seismic wave speeds. (Units 5–6)

SEISMIC ENERGY The energy transmitted through the Earth from an earthquake or an explosion. (Units 5–6)

SEISMIC REFRACTION The change of direction of a seismic wave as it crosses from one rock type to another in which it has a different speed of propagation. (Units 5–6)

SEISMIC TRACE The record of a seismic event obtained from a seismometer. (Units 5–6)

SEISMIC ZONES Regions of the Earth's surface that are particularly prone to the occurrence and effects of earthquakes. (Units 5–6)

SEISMOLOGY The science of earthquakes (from the Greek word *seismos*, meaning a shaking). (Units 5–6)

SEISMOMETER An instrument that records the ground motion resulting from seismic disturbances (earthquakes and explosions). (Units 5–6)

SELECTIVELY NEUTRAL (biology) Description given to an allele or genotype that, when phenotypically manifested, seems not to affect fitness. (Unit 21)

SELF-EXCITING DYNAMO MODEL A model that enables the Earth's magnetic field to be understood. The model proposes that there is a series of electrical currents flowing in helical patterns within the Earth's liquid outer core, the flow being sustained by convection within the outer core. (Units 5–6)

SEMICONDUCTOR A material with an electrical conductivity whose value is intermediate between typical metallic and non-metallic values and increases with temperature. (Units 13–14)

SEMI-CONSERVATIVE REPLICATION From experimental evidence, this appears to be the correct model of DNA replication. In semi-conservative replication, new daughter helices are formed from one existing strand and one newly synthesized strand of DNA. (Unit 24)

SEMI-METAL A chemical element (such as silicon) that displays an electrical conductivity intermediate between those of metals and non-metals. (Units 13–14)

SENSORY NERVE A nerve made up of neurons that carry sensory information from receptors. (Unit 23)

SHEAR STRAIN The elastic deformation produced by shear stress. In rocks, shear strain occurs as S-waves (transverse or 'shake' waves) pass through the rocks. (Units 5–6)

SHEAR STRESS Stress that occurs in a material as a result of an applied shearing force. In rocks, shear stress occurs as S-waves (transverse or 'shake' wave) pass through the rocks. (Units 5–6)

SHELL (chemistry) See electron shell.

SHIELD VOLCANO A dome-shaped volcano formed by the rapid build-up of overlapping lava flows from a single eruptive vent. The lava must be relatively fluid and is typically basalt. (Units 7–8)

SIGNAL (biology) The passage of information from one part of an organism to another. In animals, the signal can involve nerve impulses or the secretion of hormones into the circulating blood. (Unit 23)

SIGNIFICANT FIGURES The number of accurately known digits, plus one uncertain digit, in the value of a physical quantity. (Unit 4)

SILICA The oxide of silicon, SiO_2 , that is closely allied to the polyatomic anion $(\text{SiO}_4)^{4-}$. The naturally occurring crystalline form (mineral) is quartz. (Unit 27)

SILICATE MINERALS Minerals containing the polyatomic anion $(\text{SiO}_4)^{4-}$ and combinations of these units in the form of chains, sheets or three-dimensional frameworks. Most of the common rock-forming minerals are silicates. (Unit 27)

SILL A sheet-like igneous body intruded parallel to a bedding plane of the sediments it intrudes (contrast dyke). (Units 28–29)

SIMPLE QUARK MODEL A simple model of hadronic structure according to which baryons each consist of three quarks, antibaryons each consist of three antiquarks and mesons each consist of a quark and an antiquark. (Unit 32)

SINE (SIN) In a right-angled triangle, the sine of the angle θ (written as $\sin \theta$) is given by the length of the side opposite the angle θ divided by the length of the hypotenuse. (Unit 2)

SINGLE BOND A unit of chemical bonding between two atoms; in electronic theories of bonding, it is represented by a shared pair of electrons. (Units 13–14)

SINKER EFFECT The effect by which dense oceanic lithosphere that is being subducted drags the rest of the plate (of which the subducted lithosphere is a part) towards the subduction zone. (Units 7–8)

SI UNITS SI (an abbreviation for *Système Internationale*) units are now used almost universally in the scientific world. In this Course, we use six of the seven basic SI units.

Multiples of units In many contexts, the basic SI units are too large or too small. It is then convenient to use multiple units, which are denoted by a prefix. The prefixes commonly used with SI units are listed on the back cover of this booklet. Compound prefixes should not be used. Thus 10^{-9}m is represented as 1 nm, not 1 μm . This means that although the SI unit of mass is the kilogram, the gram must be used in association with prefixes, e.g. 10^{-6}kg is written as 1 ng, not as 1 μkg .

Derived SI units These are units that are derived from the basic SI units. For convenience many of these derived units are given special names. Those used in this Course are listed on the back cover of this booklet.

Additional units Certain units are in such widespread use (e.g. minute, hour, year, mile) that they are likely to be used for the foreseeable future. Others are being phased out gradually (e.g. gallon, inch). A few non-SI units are so convenient for scientists that, although strictly speaking there is no need for such units, they are being retained. Three such units are used frequently in this Course:

- the litre ($1 \text{ l} = 10^{-3} \text{ m}^3 \approx 1 \text{ cm}^3$);
 - the electronvolt ($1 \text{ eV} \approx 1.602 \times 10^{-19} \text{ J}$);
 - the degree Celsius (temperature in degrees Celsius = temperature in kelvin – 273.15).
- (Unit 2)

SKELETAL ISOMERS Two molecules are skeletal isomers if they are structural isomers which have different molecular backbones. An example of such a pair is butane, $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_3$, and 2-methylpropane, $\text{CH}_3\text{—CH—CH}_3$. (Units 17–18)



SLATE A fine-grained metamorphic rock formed by the recrystallization of a mudrock. It is characterized by a well-developed cleavage resulting from alignment of platy minerals. (Unit 27)

SMALL-ANGLE APPROXIMATION For a circle, the length of a curved arc can be approximated by a straight line provided that the angle subtended at the centre by the ends of the arc is less than about 15° . (Unit 2)

SNELL'S LAW When a wave crosses the boundary between two media in which it has different speeds of propagation, the relationship that describes the path followed by the wave is

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

where i is the angle of incidence, r is the angle of refraction, and v_1 and v_2 are the wave speeds in the two media. (Units 5–6)

SOLAR DAY The interval between two consecutive culminations of the Sun (observed from the same point on Earth). (Unit 1)

SOLAR SPECTRUM The spectrum of the Sun, seen as absorption lines within a continuous emission. (See also Fraunhofer lines). (Units 11–12)

SOLAR SYSTEM The bodies (notably the planets and their moons) that orbit the Sun. (Unit 1)

SOLENOID A helical coil of wire that generates a dipolar magnetic field when an electric current passes through it. (Units 5–6)

SOLUBILITY OF A SOLUTE The concentration of the solute in a saturated solution. It varies with the temperature of the solution. (Unit 15)

SOLUTE Any ingredient of a solution other than the solvent. (Units 13–14)

SOLUTION A homogeneous material formed by the absorption of one substance, the solute, into another, the solvent, in such a way that the solvent preserves its physical state and, in large measure, its chemical structure. (Units 13–14)

SOLVENT One of two ingredients which can form a solution. It is the ingredient present in the greater amount, and undergoing the lesser change in its physical state and chemical structure. (Units 13–14)

SOMATIC CELLS They are diploid cells, and include all the cells in a multicellular organism, apart from the gametes. Also called body cells. (Unit 20)

SORTING (Earth sciences) Sorting is a quantitative term often used qualitatively, and is a measure of the distribution of grain sizes in a sediment. If many of the particles fall within a narrow range of sizes the sediment is said to be well sorted. If a wide range of particle sizes is present in a sediment it is said to be poorly sorted. (Unit 27)

SOUND ENERGY The form of energy associated with the vibrations of the atoms (or molecules) in air or another medium. (Unit 9)

SOUTH POLE OF A MAGNET The end of a bar magnet that is attracted towards the Earth's magnetic pole in the Southern Hemisphere. (Units 5–6)

s-p-d-f NOTATION The notation used to indicate the subshell that electrons occupy according to the value of the second quantum number; s denotes $l = 0$, p denotes $l = 1$, d denotes $l = 2$, f denotes $l = 3$. (Units 11–12)

SPECIAL THEORY OF RELATIVITY A theory of space and time, first formulated by Einstein in 1905. According to the theory, the energy E that is equivalent to mass m is given by $E = mc^2$ (Einstein's equation) (Unit 31)

SPECIATION The process by which new species are formed. (Unit 21)

SPECIES When members of different populations can mate and produce fertile offspring, they are said to belong to the same species. Populations that are reproductively isolated are defined as belonging to different species. (Unit 21)

SPECIFIC HEAT, c The ratio of ΔQ , the heat transferred to a unit mass of a substance, to ΔT , its corresponding change in temperature: $c = \Delta Q / \Delta T$. The SI unit of specific heat is $\text{J kg}^{-1} \text{K}^{-1}$. (Unit 9)

SPECIFIC ROTATION The specific rotation of a substance is defined by the equation $[\alpha]_D = \alpha/cl$, where α is the angle that the front polarizer in a polarimeter has to be rotated through to prevent light transmission through the sample, c is the concentration in g cm^{-3} and l is the path length of the cell in dm (10^{-1} m). The D stands for the D line in the atomic spectrum of sodium, which gives rise to the characteristic colour of the sodium lamp most frequently used for the determination of specific rotation. (Units 17–18)

SPEED The magnitude of velocity. Unlike velocity, speed is not a directional quantity. The SI unit of speed is m s^{-1} . (Unit 3)

SPEED OF LIGHT IN A VACUUM To a good approximation, the speed of light (or of any other type of electromagnetic radiation) in a vacuum (and in air) is $3 \times 10^8 \text{ m s}^{-1}$. The speed of light in a vacuum is now defined to be exactly $2.997\,924\,58 \times 10^8 \text{ m s}^{-1}$. (Unit 10)

SPERM A male gamete. In animals, it is also known as a spermatozoon (plural spermatozoa). In plants, the male gamete is more correctly called a sperm cell, and is contained in the pollen grain. (Unit 20)

SPHERICAL AVOCADO PEAR MODEL A model for understanding the structural subdivisions of the Earth into crust (analogous to the skin of a spherical avocado pear), mantle (analogous to the flesh) and core (analogous to the central stone). (Units 5–6)

SPINDLE Arrangement of fibres in the cell that are responsible for bringing about the movements of the chromosomes during meiosis. Both spindle fibres and kinetochore fibres together form the spindle. (Unit 20)

SPIN OF AN OBJECT A type of motion in which an object rotates about a (normally imaginary) line, called the axis of rotation, within the object. (Unit 1)

SPIRACLES The valves via which the tracheal system of insects, which carries air to the tissues, opens to the atmosphere. (Unit 23)

SPLICING See tailoring and splicing.

SPLIT GENES A term used to describe genes in which coding sequences of bases (exons) are interspersed with non-coding sequences of bases (introns). (Unit 24)

SPONTANEOUS NUCLEAR FISSION A process in which an atomic nucleus spontaneously undergoes fission. (Unit 31)

STANDARD DEVIATION A quantity related to the spread in repeated readings of a particular quantity. The greater the spread, the greater the standard deviation. (Unit 4)

STANDING WAVE A regularly oscillating wave that exists within fixed boundaries. For a standing wave in one dimension, there are always a whole number of half-wavelengths between the two fixed ends. (Unit 30)

STAR One of the vast number of incandescent celestial objects that can be seen in the night sky. (This is not a rigorous definition, but it is adequate for our purposes.) (Unit 1)

STEARIC ACID A long-chain fatty acid (C_{18}) produced from fats by hydrolysis. (Unit 22)

STEREISOOMERS A pair of molecules are stereoisomers if they have the same structural formula but differ in the arrangement of their atoms in space. (Units 17–18)

STOMATA (singular STOMA) Small pores in the surface (epidermis) of leaves through which carbon dioxide, oxygen and water vapour pass. (Unit 22)

STONY-IRON METEORITE A meteorite composed of silicate mineral grains in an iron nickel matrix. (Units 28–29)

STONY METEORITE A meteorite composed predominantly of silicate minerals (e.g. olivine and pyroxene). (Units 28–29)

STOP CODONS Specific codons (sequences of three bases) that signal the completion of the polypeptide chain. Of the 64 codons in mRNA, three are stop codons, namely UAA, UAG and UGA. Stop codons do not code for amino acids. (Unit 24)

STRAIN (physics) For a sample of material that is subject to stress, the strain is equal to the change in length of the sample (due to the stress) divided by the original length of the sample. (Units 5–6)

STRAIN (biology) Genotypic and phenotypic variants of organisms of the same species.

STRAIN ENERGY The form of energy that is stored in an object as a result of it having been deformed. (Unit 9)

STRANGENESS A property, generally denoted by S , that characterizes each hadron and quark. (The strangeness of every lepton and gauge boson is zero.) Strangeness is conserved in strong interactions (and in electromagnetic interactions but not in weak interactions). (Unit 32)

STRATIGRAPHIC COLUMN The array of geological time units that results from stacking them vertically with the oldest at the base overlain by successively younger units. Initial capitals (Stratigraphic Column) are used only when the array refers to *all* the Eras and Periods in Earth History. (Units 28–29)

STRATIGRAPHIC SEQUENCE The arrangement of beds or rock units in the order in which they were deposited. (Units 28–29)

STRATUM (plural strata) A particular sedimentary rock unit. Rocks with layering may be described as stratified. (Units 28–29)

STRESS The perpendicular force applied to a material per unit area. The SI unit of stress is Nm^{-2} . (Units 5–6)

STRETCH RECEPTORS Receptors that respond to stretching in the tissue in which they are located. Where they are located in the walls of blood vessels near the heart, they provide information about, for example, the blood pressure. (Unit 23)

STROKE VOLUME The volume of blood pumped out by the heart during a single contraction. See cardiac output. (Unit 23)

STROMATOLITES Structures formed in sedimentary rocks by the activity of blue-green bacteria. (Units 28–29)

STRONG ACID An acid that, when dissolved in water, is virtually completely dissociated into $\text{H}^+(\text{aq})$ and the accompanying aqueous anions. (Unit 15)

STRONG BASE A base that, when dissolved in water, is virtually completely dissociated into $\text{OH}^-(\text{aq})$ and the accompanying aqueous cations. (Unit 15)

STRONG ELECTROLYTE A substance that, when dissolved in water, is virtually completely dissociated into ions. (Unit 15)

STRONG INTERACTION The type of interaction that is responsible for the binding together of protons and neutrons in nuclei. (Unit 31)

The interaction is felt by all hadrons. (Unit 32)

STRONG INTERACTION BETWEEN QUARKS The type of fundamental interaction that is mediated by gluons. This type of interaction is responsible for the binding together of quarks (and antiquarks) in hadrons. (Unit 32)

STRUCTURAL FORMULA A representation of atoms and bonds in a molecule that shows the order in which the atoms are connected together as well as all the bonds involved. For example, the structural formula of

methanol is $\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{O}-\text{H} \\ | \\ \text{H} \end{array}$. However, the full structural

formula of even a moderate-sized molecule is very cumbersome, and so a simplified version called the abbreviated structural formula is generally used instead (for example CH_3-OH , or even CH_3OH , for methanol). (Units 17–18)

STRUCTURAL GENE A gene which can be transcribed to make an mRNA molecule that can then be translated to form a polypeptide chain. (Unit 24)

STRUCTURAL ISOMERS A pair of molecules are structural isomers if they have the same molecular formula but differ in the order in which the atoms are connected. (Units 17–18)

SUBDUCTION The process by which oceanic lithosphere is conveyed down into the mantle at a destructive plate margin. (Units 7–8)

SUB-GROUPS A and B (chemistry) The two divisions of a Group made by Mendeléeve in his short Periodic Table. The resemblances between the elements in a sub-Group are closer than those between the elements in the Group as a whole. (Units 13–14)

SUBSPECIES Part of a population that has minor genotypic and phenotypic differences from another part of the population. Although the flow of genes from one part of the gene pool to the other is restricted, the gene pool has not separated completely. Thus, reproductive isolation, and hence speciation, have not yet occurred. A synonym for subspecies is race. (Unit 21)

SUBSTRATE The term applied to any reactant of an enzyme-catalysed reaction. (Unit 22)

SUBSTRATE LEVEL PHOSPHORYLATION The production of ATP in glycolysis and the tricarboxylic acid cycle that does not involve electron transport chain activity. (Unit 22)

SUCCESSION The sequence of species that replace one another in an area from the initial stages of colonization until a climax community is achieved. (Unit 25)

SUCCESSIVE IONIZATION ENERGIES The energies required to remove successively each of the electrons from an atom, beginning with the least tightly bound electron and proceeding to the most tightly bound. (Units 11–12)

SUGAR A collective term for monosaccharides, disaccharides, trisaccharides, etc. The characteristic properties of sugars are sweetness and solubility. (Unit 22)

SUN-SPOT CYCLES The periodicity of the appearance of large numbers of dark cool patches on the surface of the Sun. (Units 28–29)

SUPERPOSITION OF WAVES (physics) See constructive and destructive superposition, and principle of superposition. (Unit 10)

SURVIVORSHIP CURVE A graphical representation of the data in a life table. (Unit 25)

SUSPENDED LOAD Particles carried within a flowing medium. (Unit 27)

S-WAVES Transverse seismic waves produced by shearing motions. They were called S-waves because they are the second set of waves that arrive from an earthquake. (Units 5–6)

S-WAVE SHADOW ZONE The zone of the Earth at epicentral angles of more than 103° from an earthquake epicentre, beyond which no S-waves arrive from the earthquake. (Units 5–6)

SYMPATHETIC NERVOUS SYSTEM In vertebrates, the sympathetic nervous system is a part of the nervous system that is not under voluntary control. It carries motor (movement) instructions from the brain and spinal cord. Where it interacts with the parasympathetic system (e.g. in the heart) it often acts antagonistically. (Unit 23)

SYNCHROTRON A circular (or nearly circular) accelerator of charged particles. (Unit 32)

SYNTHESIS (biology) The production of molecules within an organism from other molecules that are different from, and usually simpler than, the end product. (Unit 19)

SYSTEMATIC ERROR The kind of error of observation that systematically shifts all readings in the same direction away from the true value. (Unit 3)

SYSTEMIC CIRCULATION The route taken by blood when it leaves the left ventricle of the heart, passing through the aorta and a system of arteries and arterioles to the capillaries in all parts of the body, then returning to the right atrium via a system of veins. Together with the pulmonary circulation, it forms the double circulation. (Unit 23)

T

TAILORING AND SPLICING A colloquial term used to describe the way mRNA is modified after transcription, so that the non-coding sequences (introns) are 'tailored out' and the coding sequences (exons) are 'spliced' together. (Unit 24)

TANGENT (TAN) In a right-angled triangle, the tangent of the angle θ (written as $\tan \theta$) is given by the length of the side opposite the angle θ divided by the length of the shorter side adjacent to the angle. (Unit 2)

TANGENT TO A CIRCLE A straight line that touches the circumference of a circle at only one point. (Unit 2)

TARGET TISSUE The site where a hormone exerts its effect. This is normally a different place from where the hormone is synthesized. (Unit 23)

TAXONOMIC HIERARCHY When species of organisms are classified, they are arranged in progressively larger and larger groups, each of which contains the previous groups. Similar species are collected into a genus. Similar genera are collected into a family, families into an order, orders into a class, classes into a phylum, and phyla into a kingdom. There are other more detailed categories. (Unit 21)

TAXONOMY The study of the theory, practice and rules of classifying living and extinct organisms. (Unit 21)

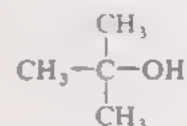
TECTONICS Study of the large-scale movements of the Earth's crust and the resulting structures. See also plate tectonic theory. (Units 7–8)

TELEOLOGICAL STATEMENTS (biology) Descriptions of biological systems in terms that imply purpose in design. Such statements are recognizable because they contain phrases like 'in order to' or 'so that'. Teleological statements are not desirable in biology because they do not conform with our understanding of evolution by natural selection. (Unit 23)

TELOPHASE See meiosis and mitosis.

TERRANE A fragment of continental crust that has internally consistent geological features and is bounded by horizontal faults or melange zones. (Units 7–8)

TERTIARY ALCOHOL An alcohol in which the hydroxyl group is attached to a carbon atom that itself is attached to three other carbon atoms; for example, 2-methylpropan-2-ol:



(Units 17–18)

TESLA, T The SI unit of magnetic field strength. Measured in this unit, the strength of the Earth's magnetic field is about 10^{-4} to 10^{-5} T at the surface, while a bar magnet from the Experiment Kit would give about 10^{-1} T at its ends. The formal definition is beyond the scope of this Course. (Units 5–6)

TEXTURE OF A ROCK The description of the particles a rock is made from and of the relationship between them. Texture can be fragmental (sedimentary rocks) or crystalline (igneous rocks). (Units 5–6)

Metamorphic rocks show a crystalline texture but often display mineral orientation or banding. (Unit 27)

THERMAL DENATURATION The progressive destruction of the higher-order structure of proteins when the temperature is increased. (Unit 22)

THERMAL GRADIENT (Earth sciences) The increase in temperature with depth in the crust, expressed in terms of degrees Celsius per kilometre. A thermal gradient may be $10\text{--}15^\circ\text{C km}^{-1}$, beneath stable continental areas (cratons), but may exceed 30°C km^{-1} beneath continental zones that are tectonically active. (Unit 27)

THOUGHT EXPERIMENT An experiment done not with actual apparatus, but with the aid of logical reasoning. This reasoning is normally based on results and principles that have been well-tested in experiments done with real apparatus. (Unit 1)

THREE-DIMENSIONAL MOTION Motion of a particle whose position (at each point along its path) is completely specified by a triplet of position components (e.g. x, y, z) with respect to a fixed set of axes. (Unit 30)

THRESHOLD FREQUENCY A frequency of electromagnetic radiation below which the radiation cannot eject electrons from a particular solid. Each solid has a characteristic threshold frequency. (Unit 10)

THRUST A low-angle fault caused by compression, in which rocks on the upper side of the fracture move up relative to the rocks on the lower side. The angle between the fault plane and the horizontal is less than that of a reverse fault. (Unit 27)

THYMINE (T) One of the four organic bases that are components of deoxyribonucleotides. It has a one-ring structure known as a pyrimidine ring. Its structure is similar to that of uracil, which is found in ribonucleotides. (Unit 24)

TILL (boulder clay) A poorly sorted sediment, often containing far-travelled stones in a clay matrix, deposited directly by a glacier or ice sheet. (Units 7–8)

TISSUE A structure of a particular type found within an organ. Examples are muscle and bone. (Unit 19)

TOPNESS A property, generally denoted by T , that is believed to characterize each hadron and quark (the topness of every lepton and gauge boson is zero). It is predicted that topness will be conserved in strong and electromagnetic interactions, but not in weak interactions. (Unit 32)

TOTAL GENERATION PRE-REPRODUCTIVE MORTALITY. k_{total} The total mortality occurring in a generation from the time it starts (as a set of newly formed zygotes) to the time when the survivors of that generation begin to reproduce. k_{total} is the sum of all the contributing k -values ($k_1 + k_2 + k_3 + \dots + k_n$). It also equals the logarithm to the base ten of the ratio of the number of initial zygotes to the number of individuals that survive to sexual maturity. (Unit 25)

TOTAL REFLECTION The reflection of all the energy of a wave that meets a boundary between two media. This will occur where the angle of incidence is equal to or greater than the critical angle. (Units 5–6)

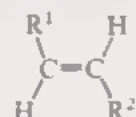
TRACHEAL SYSTEM (TRACHEA, plural TRACHEAE) Network of tubes in insects that convey oxygen to the tissues, and remove carbon dioxide. The windpipe in humans is also known as the trachea. (Unit 23)

TRANSCRIPTION The synthesis of an RNA molecule using a DNA molecule as a template. (Unit 24)

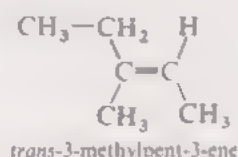
TRANSFER RNA, tRNA Small RNA molecules involved in protein synthesis. Each one carries a particular amino acid from the cytosol to a ribosome attached to an mRNA molecule. (Unit 24)

TRANSFORM FAULT A fault across which relative sideways movement is taking place between adjacent lithospheric plates. This is a conservative plate margin. Transform faults are terminated by ('transformed' into) fundamentally different structures, such as ocean ridges or ocean trenches. (Units 7–8)

trans ISOMER A molecule containing a carbon-carbon double bond with the following stereochemistry:



where R^1 and R^2 are two groups (or atoms other than hydrogen) that can be the same or different. For compounds such as 3-methylpent-3-ene (see below), it is the relationship of the larger of the groups at each end that determines which isomer is called *trans*. (See also *cis* isomer.)



(Units 17–18)

TRANSITION ELEMENTS A set of chemical elements that span a region of the Periodic Table in which a d shell in the free atoms is being filled. As so defined in this Course, they consist mainly of the three series, Sc to Zn, Y to Cd, and Lu to Hg. (Units 13–14)

TRANSITION ZONE That part of the mantle lying between depths of 400 km and 1050 km, within which the internal structure of the peridotite in the upper mantle is transformed by a series of phase changes. (Units 5–6)

TRANSLATION The process of synthesis in the cytoplasm of polypeptides (proteins) using information about the amino acid sequence encoded in mRNA. In addition to mRNA, translation also involves ribosomes, tRNA molecules, enzymes and ATP. (Unit 24)

TRANSVERSE WAVE MOTION The passage of 'shake' pulses which cause sideways motion in the medium through which they pass (i.e. the medium vibrates at right angles to the direction of wave propagation). In this type of wave motion, there is a change in the shape of the medium as the wave passes, but no change in volume. (Units 5–6)

TRICARBOXYLIC ACID CYCLE (TCA CYCLE) A sequence of enzyme-catalysed reactions that occurs in the mitochondrial matrix. A C_4 acceptor molecule (oxaloacetic acid) reacts with a C_2 molecule (acetyl CoA) to form a C_6 molecule (citric acid). The cyclic sequence of reactions now re-forms oxaloacetic acid, the C_2 part being converted en route into 2CO_2 . During this cyclic conversion, three molecules of NADH_2 , one of FADH_2 and one of ATP (by substrate level phosphorylation) are produced. The TCA cycle is involved in the catabolism of glucose, fatty acids and amino acids. (Unit 22)

TRIGLYCERIDE See fat (Unit 22)

TRILOBITE Extinct group of crawling animals, with compound eyes, and three-lobed segmented bodies, distantly related to crabs; confined to the Palaeozoic Era. (Units 28–29)

TRIPLE BOND A bond between two atoms of a chemical substance, equivalent to three single bonds; in electronic theories of bonding, it is represented by three shared pairs of electrons. (Units 13–14 and 17–18)

TRIPLET CODE A description of the genetic code, indicating that the identity of an amino acid is coded for (in DNA and in mRNA) by a sequence of three bases. This sequence of three bases is called a codon. (Unit 24)

tRNA See transfer RNA. (Unit 24)

tRNA ANTICODON A sequence of three unpaired bases in each tRNA molecule, complementary to a codon on the mRNA. (The tRNA anticodon will have the same sequence of bases—but with uracil replacing thymine—as the sequence of bases in DNA that coded for the mRNA codon.) (Unit 24)

TROPHIC LEVEL The position that an organism occupies in a food chain. (Unit 25)

TROUGH OF A WAVE A position of maximum displacement of a wave, relative to the wave's average height, in a particular direction at right angles to the direction of propagation. A position of maximum displacement in the opposite direction is called a crest. (Unit 10)

TSUNAMIS Very large ocean waves caused by earthquakes occurring beneath the ocean, the amplitudes of which grow higher near the shore. Tsunamis can be some of the most serious effects of earthquakes. (Units 5–6)

TURNOVER (biology) The balanced breakdown and re-synthesis of cellular chemicals. (Unit 22)

TWO-DIMENSIONAL MOTION Motion of a particle whose position (at each point along its path) is completely specified by a pair of position components (e.g. x , y) with respect to a fixed set of axes. (Unit 30)

TYPICAL ELEMENTS A set of chemical elements whose free atoms have outer electronic configurations of the type ns^x , where $n = 1$ to 7 and $x = 1$ or 2, or of the type ns^2np^x , where $n = 1$ to 7 and $x = 1$ to 6. (Units 13–14)

U

UNBOUND ELECTRON An electron that has sufficient energy not to be bound by, for example, an atomic nucleus. Its energy is not quantized and lies in the continuum of energies on an energy-level diagram. (Units 11–12)

UNCERTAINTY IN A MEASUREMENT An amount that indicates the experimental uncertainty in the determination of the size of a quantity. The value of the quantity is then quoted as the most likely (or average)

value, plus or minus the uncertainty. See also error bar, random uncertainty and systematic error. (Unit 2)

UNCERTAINTY IN A QUANTUM MECHANICAL MEASUREMENT For a given experimental set-up, the uncertainty in a quantum mechanical measurement of a quantity is half the spread of the measurements of the quantity. More rigorously, the uncertainty is the standard deviation of the measurements. (Unit 30)

UNCONFORMITY The boundary between two adjoining strata that were formed at different times. This is often recognized by an oblique angle between bedding planes of the adjacent strata. (Units 28–29)

UNICELLULAR Description of an organism that consists of just one cell. Some unicells (unicellular organisms) are eukaryotic, e.g. amoebae. Some are prokaryotic, e.g. bacteria. (Unit 19)

UNIVERSAL CONSTANT A constant that is believed to have the same value throughout the Universe. An example of a universal constant is the gravitational constant, G . (Unit 3)

UNIVERSE The totality of everything that exists. (Unit 1)

UNPAIRED ELECTRON An electron (in an atom) that is not paired with an electron of opposite spin. (Units 11–12)

UNSATURATED COMPOUND A compound with molecules containing one or more double or triple bonds. (Units 17–18)

UPPER AND LOWER LIMITS The maximum and minimum values that a quantity is likely to have, according to a given set of measurements. (Unit 2)

UPPER MANTLE The part of the mantle that lies between the crust (the base of which is marked by the Mohorovičić discontinuity at depths from 6 to 90 km) and the top of the transition zone (at 400 km depth). (Units 5–6)

URACIL (U) An organic base that is a component of ribonucleotides. It has a one-ring structure known as a pyrimidine ring. Its structure is similar to that of thymine, which is found in deoxyribonucleotides. (Unit 24)

URANINITE A mineral with composition U_3O_8 . (Units 28–29)

UREA An organic compound of nitrogen with the molecular formula $CO(NH_2)_2$. It is the principal form in which waste nitrogen is excreted from many animals, including humans. (Unit 23)

V

VALENCY A property of an element that describes its ability to combine with other elements. The valency is equal to the number of atoms of hydrogen that combine with one atom of the element (or, if the element does not combine with hydrogen, its valency is worked out from the known valency of another element with which it *does* combine). For example, in ammonia (NH_3) the valency of nitrogen is three. (Units 13–14)

VARVE A layer of sediment deposited in a single year. (Units 28–29)

VEINS Thin-walled blood vessels that carry blood towards the heart. (Unit 23)

VELOCITY The rate of change of position with time, specified in terms of both a magnitude and a direction (cf. speed). The SI unit of (magnitude of) velocity is ms^{-1} . (Unit 3)

VENA CAVA Main vein of mammals (and some other vertebrates) that returns blood to the heart. (Unit 23)

VENTRICLE One of the chambers of the heart, with very muscular walls. It receives blood from the atrium and pumps it out through the arteries. The mammalian heart has two ventricles, the amphibian heart has one. (Unit 23)

VESICULAR BASALT Basalt containing gas bubbles due to formation from a gaseous magma (a vesicle is a cavity). Also called frothy basalt. See pumice. (Units 5–6)

VIABILITY (biology) An organism's ability to survive from being a fertilized egg through to reproductive maturity. (Unit 19)

VINE-MATTHEWS HYPOTHESIS The hypothesis that the linear magnetic anomaly patterns of the ocean floor are the result of alternately reversed and normally magnetized oceanic crust, which was created by sea-floor spreading during corresponding periods of alternating reversed and normal polarity of the Earth's magnetic field. (Units 7–8)

VISCOSITY A measure of the ease with which a fluid flows. Under ordinary conditions, treacle and motor oil have higher viscosity than water and hence flow more slowly. (Unit 23)

VISIBLE LIGHT Electromagnetic radiation that can be seen by the human eye. Roughly speaking, the range of wavelengths of visible light is 400–700 nm. (Unit 10)

VITAMIN An organic compound essential (in small quantities) for the health of an organism that it cannot synthesize. Consequently supplies have to be obtained in the diet. Some B-group vitamins are essential because certain coenzymes have particular B-group vitamins as part of their molecular structure. For example, one of the components of the hydrogen-carrying coenzyme FAD is riboflavin (vitamin B_2). (Unit 22)

VOLT, V The SI unit of voltage (potential) difference: $1 \text{ V} = 1 \text{ J C}^{-1}$. (Unit 9)

VOLTAGE DIFFERENCE The voltage at a point is the electrical energy per unit positive charge at that point. The voltage difference between two points is the difference between the voltage at one point and the voltage at the other. A positive charge will tend to move from a point with high voltage to a point with a comparatively low voltage. The SI unit of voltage difference is the volt. Voltage difference is also known as potential difference. (Unit 9)

W

WADATI-BENIOFF ZONE An inclined zone of earthquake foci that dips down to not more than 700 km beneath the continents from a deep ocean trench, and is associated with subduction at a destructive plate margin. Formerly known as a Benioff zone. (Units 7–8)

WATT, W The SI unit of power. One watt is defined as one joule per second: $1 \text{ W} = 1 \text{ J s}^{-1}$. (Unit 9)

WAVEFRONT A surface over which the phase of a wave is constant. (Unit 10)

WAVEFUNCTION A quantum mechanical wave that specifies mathematically the behaviour of a quantum of matter. (Unit 30)

WAVELENGTH The distance between two successive identical points on a wave pattern, measured along the direction of wave propagation. (Units 5–6)

Wavelength λ is related to the wave frequency f and the wave speed v by the equation $v = f\lambda$. (Unit 10)

WAVE-PARTICLE DUALITY A colloquial expression of the fact that in order to understand the behaviour of light (and of any other type of electromagnetic radiation) in macroscopic terms, two models are required—a wave model and a particle model. In fact, light is neither waves nor particles, although it does sometimes *behave* as though it were a wave, and sometimes as though it were particles. (Unit 10)

Similarly, there is a wave-particle duality in the behaviour of matter. (Unit 30)

WEAK ACID An acid that, when dissolved in water, is only partly dissociated into $\text{H}^+(\text{aq})$ and the accompanying aqueous anion. (Unit 15)

WEAK BONDS (biology) Collective term for the non-covalent bonds involved in the structure of proteins, nucleic acids and other biological polymers. They include hydrogen bonds and ionic interactions. See also intermolecular forces. (Unit 22)

WEAK ELECTROLYTE A substance that, when dissolved in water, is only partially dissociated into ions. (Unit 15)

WEAK INTERACTION A type of fundamental interaction that is mediated by an intermediate vector boson. This type of interaction is ultimately responsible for radioactive β^- - and β^+ -decays. (Note that the weak interaction has nothing to do with weak bonds.) (Unit 32)

WEATHERING The breakdown of rocks at the Earth's surface by geological processes. The two main types of weathering are chemical weathering and physical weathering. (Unit 27)

WEIGHT The attractive gravitational force exerted on an object by the Earth (or the Moon or some other massive body). Near the surface of the Earth, the weight of an object is given by the product of the object's mass and the acceleration due to gravity on Earth. The direction in which the weight acts is towards the centre of the Earth. (Unit 3)

WEINBERG-SALAM THEORY A unified theory of weak and electromagnetic interactions. (Unit 32)

WHITE CELLS The white cells in the blood form an important part of the defence systems of the body. There are a number of different types. They have nuclei, unlike red cells (in mammals) and platelets. (Unit 23)

WHITE LIGHT Light containing all the colours (wavelengths) within the visible spectrum, at approximately equal intensities. (Unit 10)

WIDMANSTÄTTEN PATTERNS A texture found in certain iron meteorites resulting from the separation of two iron-nickel alloys during cooling. (Units 28-29)

WOBBLE HYPOTHESIS A hypothesis proposed to explain the degenerate nature of the genetic code. (Unit 24)

WORK FUNCTION, ϕ The work function of a given solid is the minimum energy required to eject an electron from the solid. (Unit 10)

Z

ZEEMAN EFFECT The splitting of spectral lines in the presence of a magnetic field, caused by the effect of the magnetic field in removing the degeneracy of energy levels within electron subshells. (Units 11-12)

ZONATION The banded pattern of distribution of species often seen on an environmental gradient. The organisms on a rocky shore are typically distributed in this kind of pattern: here the environment is graded from very wet to dry. (Unit 25)

ZONE (Earth sciences) A stratum or layer of sedimentary rock characterized by a particular fossil, or group of fossils. (Units 28-29)

ZOOPLANKTON Plankton composed of animals (the Greek word *zoo* means animal). Plankton is the collective name for small water-borne organisms, and includes zooplankton and phytoplankton. (Unit 25)

ZYGOTE The product of the fusion of a male gamete with a female gamete. The zygote develops into an adult organism by mitosis. The term is applicable to both plants and animals. (Unit 20)

USEFUL INFORMATION FOR S102

THE GREEK ALPHABET

alpha	A	α	iota	I	ι	rho	P	ρ
beta	B	β	kappa	K	κ	sigma	Σ	σ
gamma	Γ	γ	lambda	Λ	λ	tau	T	τ
delta	Δ	δ	mu	M	μ	upsilon	Y	υ
epsilon	E	ϵ	nu	N	ν	phi	Φ	ϕ
zeta	Z	ζ	xi	Ξ	ξ	chi	X	χ
eta	H	η	omicron	O	o	psi	Ψ	ψ
theta	Θ	θ	pi	Π	π	omega	Ω	ω

SI UNITS USED IN S102

Physical quantity	Name of unit	Symbol	Physical quantity	Name of unit	Symbol
length	metre	m	electric current	ampere	A
mass	kilogram	kg	temperature	kelvin	K
time	second	s	amount of substance	mole	mol

PREFIXES FOR MULTIPLES OF UNITS

Mult. factor	Prefix	Symbol	Mult. factor	Prefix	Symbol
10^{-1}	deci	d	10^1	deca	da
10^{-2}	centi	c	10^2	hecto	h
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	μ	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P

DERIVED SI UNITS USED IN S102

Physical quantity	Name of derived unit	Symbol	Derived unit (in SI)
force	newton	N	$\text{kg m s}^{-2} = \text{J m}^{-1}$
energy	joule	J	$\text{kg m}^2 \text{s}^{-2} = \text{N m}$
power	watt	W	J s^{-1}
electric charge	coulomb	C	A s
electric potential difference	volt	V	$\text{J A}^{-1} \text{s}^{-1}$
magnetic field strength	tesla	T	$\text{N m}^{-1} \text{A}^{-1}$
frequency	hertz	Hz	s^{-1}

S102 UNITS

1	Science and the planet Earth	19	Life and evolution
2	Measuring the Solar System	20	Inheritance and cell division
3	Motion under gravity	21	Genes and evolution
4	Practical work in science	22	Biochemistry
5-6	Into the Earth: earthquakes, seismology and the Earth's magnetism	23	Physiology
7-8	Plate tectonics: a revolution in the Earth sciences	24	DNA: molecular aspects of genetics
9	Energy	25	Ecology
10	Modelling the behaviour of light	26	Biology reviewed
11-12	Atomic structure	27	Earth materials and processes
13-14	Chemical reactions and the Periodic Table	28-29	Geological time and Earth history
15	Chemical equilibrium	30	Quantum mechanics: an introduction
16	Chemical energetics	31	Quantum mechanics: atoms and nuclei
17-18	The chemistry of carbon compounds	32	The search for fundamental particles